The Blast Furnace and Steel Plant

Electrical Development in the Steel Industry

Brief Review of the Recent Developments and Applications of Electricity in Refining and Rolling Steel—Shows Tremendous Increase in the Use of Electric Power in Mills.

By A. G. AHRENS,

Commercial Engineer, Westinghouse Electric & Manufacturing Company.

The unprecedented prosperity of the steel industry during the last three years, that is, during the period of the war, is reflected in the very decided increase in the application of electric power in the mills. It is probable that the present enormous output of steel would have been impossible without the use of electricity, which has helped in the making, refining and rolling of the steel. Great credit is due to the electric central station companies, who are supplying power to the steel plants. In many cases their energy and foresight had made expansion of steel plants possible in a few months, when years would have been required if the steel company had been obliged to build their own power generating stations.

These three years have seen the starting of the Central Steel Company's plant at Massilon, Ohio, the first to carry out every mechanical operation by electricity. The success of this effort is attested by the fact that this company is now one of the largest and most successful producers of alloy steels in this country, and our Government is depending on it for a large part of the special steels required for the construction of aeronautical engines and airplanes.

An alternating-current motor and control for operating the blast furnace skip hoist has recently been developed and put into successful service.

There are now in this country about 150 electric furnaces installed or on order. Over 100 of these have been installed during the last three years. Of these, about 70 were contracted for within the last year. The electric furnace steel production for 1917 will be approximately 300,000 tons, most of which will be used under Government's direction. This is an increase of 65 per cent over the previous year. Needless to say, this is a timely increase so far as Government needs are concerned.

Electrification of the main rolls has contributed largely to the increased efficiency and greater output of the steel mills. To-date about 700,000 horsepower in main roll motors of 300 horsepower capacity and above, have been installed. Over one-half of these were contracted for since the war began.

The war has made possible new records in the capacity of motors for rolling mills; the great demand for ship plates and munition steel having made necessary production in greater volume than ever before. Among the large and interesting electrical units for steel mill service is a reversing mill drive now being constructed for the 60 inch Universal Universal Plate Mill at the plant of Bethlehem Steel Comptny, Sparrow's Point, Md. This is the largest reversing equipment ever attempted. The motor has a maximum rating of 18,600 horsepower and a maximum speed of 100 r.p.m. It is of the double armature construction, this method of construction reducing the inertia to a minimum. A thrust bearing is provided to protect the motor from the thrust which may be developed in the mill.

The reversing motor receives its power from a motor generator set with flywheel. An induction motor is now being installed at the Illinois Steel Company, Gary, Ind., for a 160-inch plate mill. This is the largest motor, both from the standpoint of continuous and maximum ratings, that has ever been built. Its continuous rating is 7000 horsepower, with a full-load speed of 81.7 revolutions per minute, and its maximum rating is four times the normal torque, this corresponding to 28,000horsepower at 81.7 r.p.m.

Another unit of large size recently completed is the 4200 horsepower induction motor driving the Morgan Continuous Mill at the plant of United Alloy Steel Corporation, Canton, Ohio. Its continuous rating is 4200 horsepower with a full-load speed of 93 r.p.m. It is the largest sixty-cycle motor that has ever been built, having a frame over 27 feet in diameter and stands over 17 feet above the floor.

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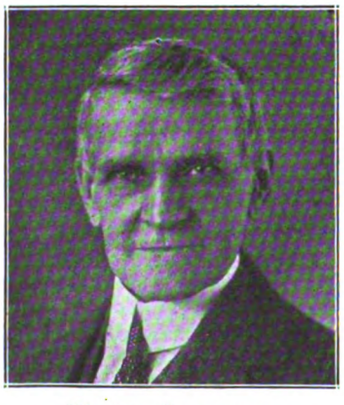
Iron and Steel Electrical Engineers

Successful Convention Marked by Large Attendance—Former U. S. Senator T. E. Burton Speaks at Eleventh Annual Dinner. Patriotic Session Addressed by President of Lehigh University.

F. D. Egan,
Steam and electrical engineer, Pittsburgh Crucible Steel Company, Midland, Pa., president of the A. I. S. E. E.

J. E. Fries,
Chief electrical engineer, Tennessee Coal, Iron and Railroad Company, Ensley, Alabama.



Walter Greenwood,
Safety engineer Carnegie Steel Company, Ohio Works, presented paper entitled "Safeguarding Electrical Equipment."

Unusually interesting technical papers, prompted by a rather serious sort of patriotism, with the aim of increasing production in the steel industry marked the keynote of the eleventh annual convention of the Association of Iron and Steel Electrical Engineers held at the Bellevue-Stratford Hotel, September 10-14 The association was formed in 1907 by a small group of electrical engineers engaged in the steel industry in the Pittsburgh district, and called together at the invitation of the Westinghouse Electric and Manufacturing Company. Its aim was to be "the advancement of the application of electricity to the iron and steel or allied industries by the coöperation of its members." At that time—electric furnaces were vague dreams, main roll drives had only just been attempted and electricity was used chiefly for auxiliary drives. To-day—300,000 tons of electric steel are predicted for 1917, and more than 600,000 horse power is being used for main roll drives. The A. I. S. E. E. has played an important part in this process, and the increasing influence of the association was evidenced at the last meeting the total attendance of which was in excess of 500.

C. A. Menk, superintendent of the electrical department of the Carnegie Steel Company, Homestead works, was elected president of the association suceeding F. D. Egan under whose direction the membership increased over 30 per cent. That Mr. Egan had accomplished his purpose in creating a greater interest among the active members of the association was demonstrated by the number of discussions of technical papers at the last convention. S. C. Coey, formerly assistant superintendent of the mechanical and electrical departments of the Youngstown Sheet and Tube Company, and now connected with Celluloid Company of America was elected first vice president. D. M. Petty, superintendent of the electrical department of the Bethlehem Steel Company, South Bethlehem, Pa., was elected second vice president. J. F. Kelly of the National Tube Company, McKeesport, Pa., and Jas. Farrington, superintendent of the electrical department of the La Belle Iron Works, Steubenville, Ohio, will continue in the capacities of secretary and treasurer respectively. Following the election of officers, the question of extending the field of the organization to include "allied industries" was discussed, no decission was reached. It is however improbable that any radical change in policy will be made in the future inasmuch as the association would lose its

D. M. Petty.
Superintendent electrical department Bethlehem Steel Company, South Bethlehem, Pa., presented paper entitled "Electric Drives for Reversing Rolling Mills.

E. Friedlander,
Superintendent electrical department, Carnegie Steel Company, Edgar Thomson Works, past president of the A. I. S. E. E.

Walter C. Kennedy,
Chief engineer Standard Seamless Tube Company, Ambridge, Pa., presented paper entitled "Heroult Electric Furnaces."

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Discuss Problems to Increase Production

Utilization of Waste Heat, Central Station Power Supply, Reversing Mill Drives, Safety Devices, Fuel Economy and Sandardization of Electrical Equipment Discussed at Technical Sessions.

Jos. McKinley,
Manager of power sales, Duquesne Light Company, Pittsburgh, Pa., presented paper entitled "Central Station Power to the Iron and Steel Industry."

Joseph G. Worker,
Manager stoker section Westinghouse Electric & Manufacturing Company.

Richard H. Rice,
Engineer General Electric Company, West Lynn, Mass., presented paper entitled "Turbo Generators."

identity if numerous other industries were to be included in the scope of its activity.

Patriotism was the dominant feature of the banquet held on Wednesday evening. Addresses were made by ex-Senator Burton, of Ohio; John B. Finley, vice president of the Federal Land Bank at Baltimore; F. D. Egan, of Pittsburgh, president of the Association of Iron and Steel Electrical Engineers; Thomas Raeburn White, of Philadelphia, and City Statistician E. J. Cattell. The toastmaster was Gano Dunn, of New York, president of the J. C. White Engineering Company. A number of former engineers who have donned the khaki were present, including Colonel J. M. Andrews, of New York, former commercial head of the steel mill sales department of the General Electric Company.

The work of the convention committee with A. H. Swartz as chairman was most efficient, which was demonstrated by the success of the convention. On Wednesday afternoon a patriotic session was addressed by Dr. Harry S. Drinker, president of Lehigh University. He emphasized the need for technically trained men in urging the continuation of collegiate studies.

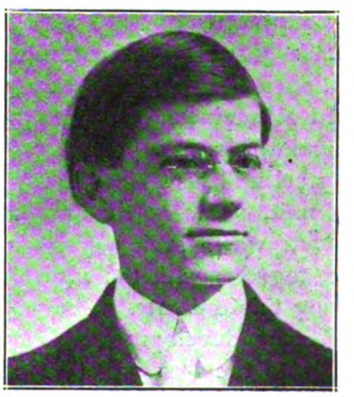
Technical Sessions.

Walter Greenwood, safety engineer, Carnegie Steel Company, Ohio Works, opened the technical session with a paper on "Safeguarding of Electrical Equipment." He discussed the general principles governing the installation of automatic engine stops, construction of electric switches, low limit for dangerous voltages, fixed stops for cranes, and the use of hot metal hoists. The paper called forth a lively discussion concerning all of these points, the main theme of which seemed to be that the education of employes is of greater importance in preventing accidents, than the addition of expensive savety first appliances, which in turn increase the cost of steel. Recommendations were made to enclose all current carrying parts and for the provisions of switches having no line parts accessible to the operator. K. H. Cederlund, C. C. McIlyar, J. S. O'Donoran, D. M. Betty, Lewis R. Rankin, A. J. Standing, E. S. Stickel, D. M. Stone, Walter C. Kennedy, C. A. Menk, E. Friedlander, F. D. Egan, Egan, A. C. Hendricks and G. W. Richardson, were among those to discuss this paper.

The operating characteristics of Heroult electric furnaces were set forth by Walter C. Kennedy, chief engineer of the Standard Seamless Tube Company, Ambridge, Pa. He described a 15-ton Heroult furnace operating on 60-cycle, three-phase current and stated, "We can reasonably expect the use of electric

A. H. Swartz,
Salesman, Westinghouse Electric & Manufacturing Company, Cleveland, Ohio, chairman of the convention committee.

R. H. McLain,
Engineer General Electric Company, Schenectady, New York, presented paper entitled "Grab Bucket Coal Hoists Operated by A-C Motors With Dynamic Braking and Regenerative Braking."



E. S. Sawtelle,
Assistant general manager of the Tool Steel Gear & Pinion Company, Cincinnati, Ohio, presented paper on "Tool Steel Gears and Pinions."

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furnaces in the future to be applied more and more in the manufacture of the lower carbon steels, as it is possible to obtain a better steel. This is true because the steel is more free from gases and oxide and also the temperature, especially at pouring, can be more accurately controlled. There are undoubtedly less bad heats with electric steel practice than with open hearth practice."

Economical Power Generation.

Brent Wiley, comercial engineer, Westinghouse Electric & Manufacturing Company, presented a paper—"Factors Relating to the Economical Generation and Use of Electric Power in the Steel Industry," in which he dealt with the proper utilization of the heat units of coke oven gas from the coke plant, blast furnace gas in pig iron production, and waste gases from open hearth and reheating furnaces. S. S. Wales, electrical engineer of the Carnegie Steel Company, in discussing Mr. Wiley's paper presented a blast furnace and steel mill heat balance based on a 500-ton production unit, showing the probable products and by-products which such a plant would consume and produce, together with the equivalents which were used in making this estimate.

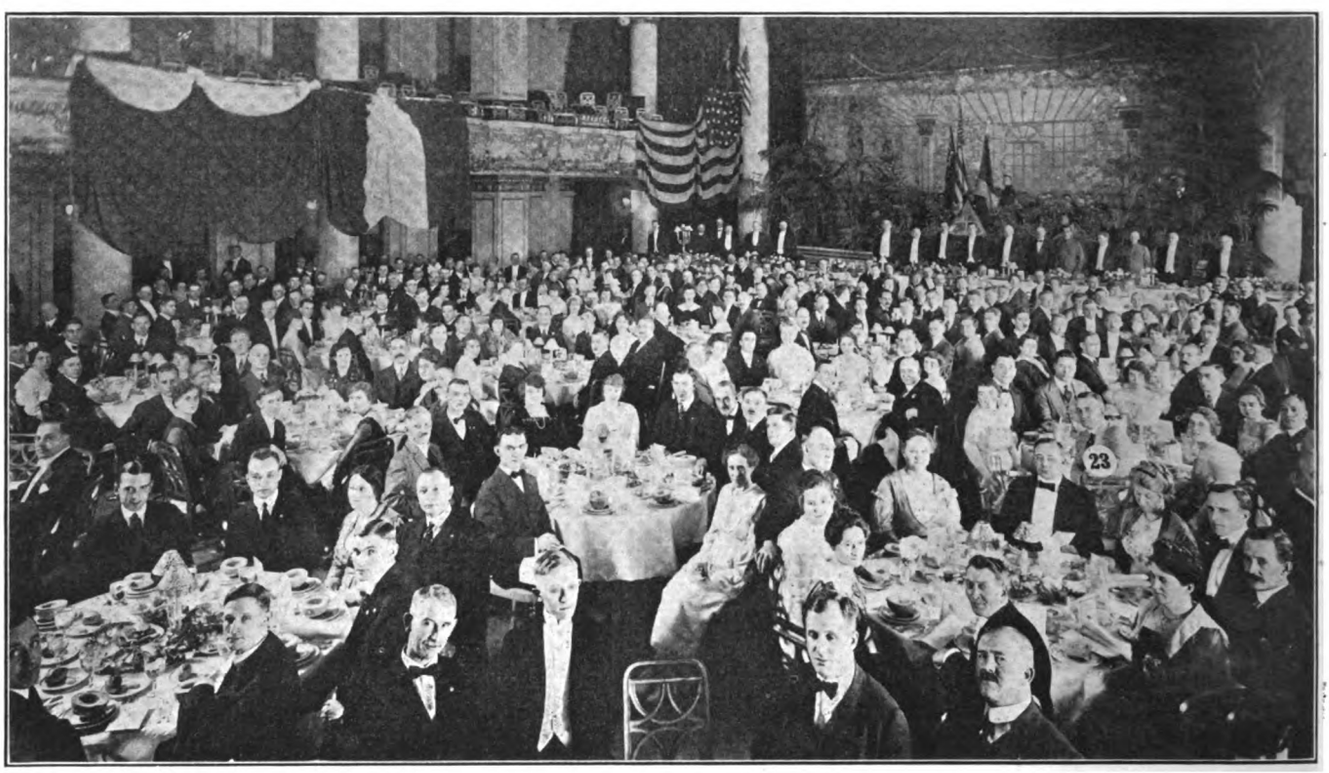
Recent developments in central station power supply to the iron and steel industry were described by a paper prepared by Joseph McKinley, manager of power sales, of the Duquesne Light Company, and Ray L. Baker, formerly power sales engineer of the Commonwealth-Edison Company, now manager of the steam and electric department of the Railway & Mine Supply Company.

Reversing Mills.

At the Tuesday afternoon session J. H. Albrecht read a paper prepared by Ralph D. Nye, electrical engineer of the United Alloy Steel Corporation, in which data was presented and comparisons made of two reversing rolling mill installations, one of which consumed 19.7 Kw.-hrs. per ton and rolled an average of 20,600 tons of steel per month. The other installation having a power consumption of 29.1 Kw.-hrs. per ton and rolling an average of 19,500 tons of steel per month.

D. M. Petty, superintendent of the electric department of the Bethlehem Steel Company stated that electric drive is to-day admitted to be superior to steam engine drive except where local conditions are very favorable to the steam engine in reading a paper entitled "Electric Drives for Reversing Rolling Mills." Both Mr. Nyes' and M. Petty's paper brought forth considerable discussion during which Mr. Wray Dudley, electrical superintendent of the Ashland Iron & Mining Company advocated a simple, reliable and adjustable current limit device which would prevent inexperienced operators from exceeding predetermined torque values while accelerating and rolling inasmuch as it would save unnecessary opening of current brakes and at the same time form maximum rolling speed.

F. B. Crosby said during his discussion: "We have demonstrated in factory tests and in actual operations



Eleventh annual banquet of the Association of Iron and Steel Electrical Engineers, held at the Bellevue-Stratford Hotel, Philadelphia, Pa., September 12, 1917.

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that a shunt motor can be designed to give more speedy operation than a compound and at the same time to meet any maximum momentary demand within the mechanical limits of the mill."

The Wednesday morning session was opened by Joseph G. Worker, superintendent of the stoker department, Westinghouse Electric and Manufacturing Company, with the reading of a paper entitled, "Fuel Economy by Co-öperation in Establishing a Better Practise in the Operation of Stokers and Boilers." He urged more attention to the methods of operation as a means of saving fuel saying "This not only includes applying the equipment in order to facilitate easy handling but also requires that particular attention be given to the character of labor used."

C. A. MENK,
Superintendent electrical department Carnegie Steel Company, Homestead Works, newly elected president of A. I. S. E. E.

Richard H. Rice of the General Electric Company, read a paper on Turbo Generators.

E. H. Martindale presented a comprehensive paper on the "Manufacture, Selection and use of Carbon Brushes."

On Thursday the standardization meeting was held in which considerable data was presented as a result of a questionaire sent to steel mills. Further standardization work was urged for the following year.

"Grab-bucket Coal Hoists Operated by a-c Motors with Dynamic Braking and Regenerative Braking" was the subject of a paper prepared by Jas. Farrington, superintendent of the electrical department of the La Belle Iron Works, and R. H. McClain, engineer, power and mining department of the General Electric Company. E. S. Sawtelle assistant general manager of The Tool Steel Gear and Pinion Company, presented an interesting paper describing a special process of hardening rolling mill pinions and gears.

The method consists in first a carbonizing proces which changes the chemical content after which the material is heat treated and quenched for hardening. The process is different to the ordinary method of case hardening gears in that different ingredients are used in the carbonizing process, giving a much deeper and more uniform penetration, and a material which is virtually free from the defects and hindrances common to the ordinary case hardened gear. 3/16-in. to ¼-in. depth of hardening is attained by the method.

Central Station Power for Steel Mills

System of Power Distribution Commonly Used—Central Station Power Supply More Reliable Than Average Steel Mill Plant. Inter-connecting of Generating Stations.

By JOSEPH McKINLEY,
Manager of Power Sales, Duquesne Light Company,
And RAY L. BAKER,
Power Sales Engineer, Commonwealth Edison Company.

The common method of supplying power to an individual customer from the Central Station system is by a single circuit tapped from a power feeder of the general distribution system. Under this scheme of operation, the copper centers of the area served are relatively close to the power user, and although there is a single source of supply of power between the copper center or sub-station and the user, these copper centers are inter-connected, thus insuring a dual supply of power from the generating station at the copper center. Needless to say where the central station covers a large area, the various centers or sub-stations may be quite remote from the generating station, but are reasonably sure of continuous source of energy. Operating under this scheme it is therefore seen that interruptions to service would only be caused by very local disturbances.

Figure 1 illustrates a typical transmission system as described above.

An Improved Method of Service Distribution.

There has been considerable development made in the past few years, where the business justified the expenditure, to perfect a scheme of distribution whereby the interruptions of the customer's service are very largely eliminated by what is known as loop line distribution from either the copper center or transmission lines, thus furnishing power supply from two sources to the customer's premises.

Figure 2 illustrates a typical loop line installation, equipped with relay apparatus. The loop line is shown in this case as originating from a sub-station. The same scheme is applicable to direct transmission lines from the generating station.

It should be noted that under this scheme of distribution, the circuit is looped through the customer's transformer vault and, therefore, such portion of this

Paper presented at the eleventh annual meeting of the Association of Iron and Steel Electrical Engineers.

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line as is located on the company's premises must be under the control of the central station.

It will be seen that where the loop line distribution is adopted, any local disturbance on any section of the loop does not affect the customer's service, unless this interruption is simultaneous at points of the loop on either side of the customer, which is exceedingly improbable.

Figure 3 is a diagram of connections of a typical transformer vault installation where the loop system is used. This figure refers to an overhead distribution circuit. A section of the overhead loop line adjacent to the company's premises, when overhead distribution is used, is installed under ground, when expense is justified, and looped into the switchhouse of the transformer vault. It is evident that by opening the overhead lines for a reasonable distance and looping the service into the transformer vault under ground, simultaneous interruption to the power supply in the vicinity of the transformer vault is minimized. The detail of this diagram is self explanatory.

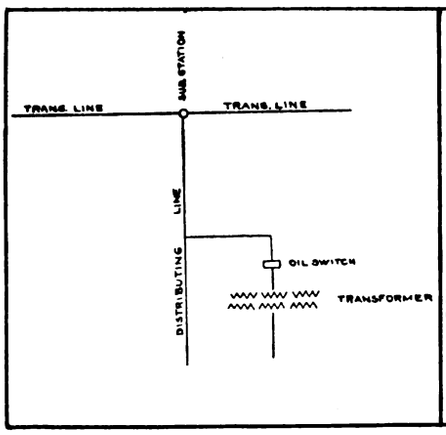

Fig. 1.—Typical transmission system.

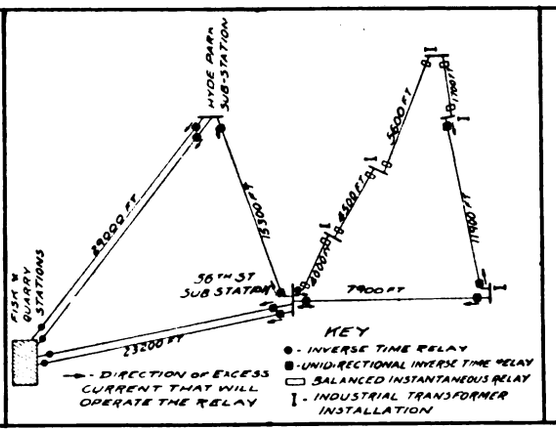

Fig. 2.—Typical loop line installation equipped with relay apparatus.

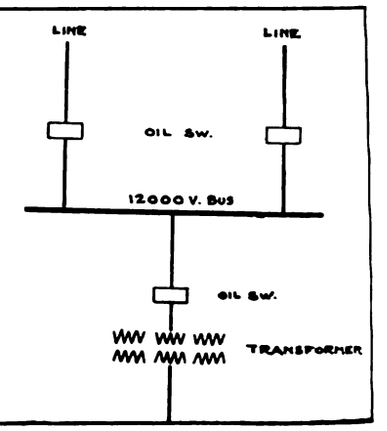

Fig. 3.—Diagram of connections of a typical transformer vault installation.

This scheme has been adopted by one of the large central stations and has been found very efficient in decreasing service interruptions caused by the elements. It should be noted that the total capacity of the loop circuit is put on a high voltage bus, through an automatically operated oil switch installed on either line.

Tying-In Generating Stations of Same Central Station.

As a further step toward furnishing uninterrupted power service to the customer, it has been the practice of the larger central station companies to interconnect its various generating plants. This arrangement further permits of the use of the loop-feed scheme in energizing the copper centers direct from these lines, and further effects a means of supplying spare capacity to any one of the power generating stations so connected in times of partial breakdown in generating equipment.

The successful results obtained in operating the generating plants of one property has suggested the further adoption of this arrangement by inter-connecting the systems of separately owned and controlled properties.

Inter-Connection of Generating Stations of Neighboring Companies.

The recent growth in high-tension transmission systems has made it possible to inter-connect the systems of neighboring central station interests. Such interconnections between generating systems doubtless located at considerable distances apart, with the power load distributed over the area between the different systems, helps eliminate power interruptions to the system, due to local storms which may occur between either station and its power user. This scheme has already been adopted in many localities and has been in successful operation for some time. The leading men of the industry, however, have under consideration the matter of very much more extensive application of this scheme of inter-connecting the large central station systems, wherever it is possible to do so. The user of central station power can, therefore, look forward to the time when his electricity may be supplied from any one of a number of power sources.

Incidentally it may be well to note that the adoption of this scheme will eliminate the smaller generating station, and will bring about the centralizing of power generation at points best conserving the power resources, including coal and water. This will naturally obtain for the consumer a minimum interrupted supply of power at the minimum cost per kilowatt-hour.

Conclusion.

In conclusion it might be well to reflect upon the results already obtained by central station companies as regards their ability to furnish a very superior class of service. The central station interests are expending a tremendous amount of money to perfect their systems to such an extent that it is safe to assume that the degree of reliability of their service could not be excelled by any plant which the average steel mill could afford to develop.

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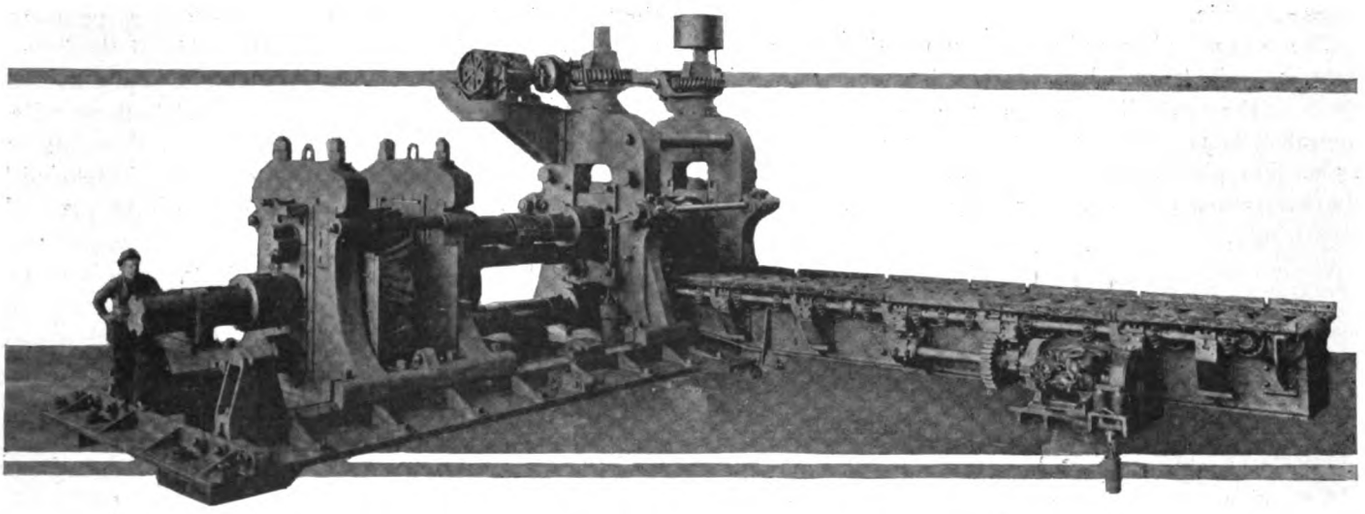


Plate Mills for Rolling Sheared Plates

Method of Rolling—Types of Mills—Production Data—Heating Furnace Suggestions—Power Requirements—Typical Arrangements and Layouts for General Purpose Mills.

By F. C. BIGGERT, JR.,
Chief Engineer, United Engineering & Foundry Company.

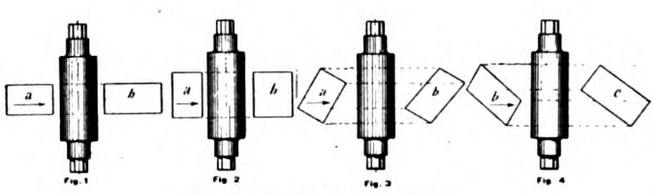
WITH the increasing demand for steel products, particularly the need for greater tonnage on the seas, many new plate mill installations are being planned and will soon be in operation. Plates are rolled either as "sheared plates" or "universal plates." In the former the plates are sheared after rolling, whereas in the latter case, the sides are rolled parallel and the metal maintained in good condition by the use of vertical rolls, so that it is only necessary to trim the ends.

Method of Rolling.

In rolling sheared plate, the operations are very different from those used in producing all other rolled products except sheets, in that the mill rolls are plain cylinders, and determine only the thickness of plate without regard to the other dimensions. The plate mill will reduce a given ingot or slab to any required thickness, but the operator must determine the width and length by his skill of eye and hand in entering the material in proper relation to the mill rolls.

When a slab is entered with its sides perpendicular to the axis of the rolls, the lateral spreading is so small as to be negligible. In Figure 1 slab "a" entering as per arrow will come out at "b" with practically no change in width, but increased in length by an amount depending upon the reduction in thickness. In Figure 2 slab "a" entering with sides parallel to the roll axis, will come out at "b" without any change in length, but with the width increased in proportion to the amount of reduction. As the width of slab used is generally not sufficient to permit of its being readily carried sidewise on ordinary roller tables, it is inconvenient to enter the mill as in Figure 2, but as it is necessary to spread the slab in this direction, an expedient is resorted to by entering diagonally, as in Figure 3. The slab "a" entering diagonally in Figure 3, is reduced to a "diamond" shape at "b," and by again entering on the opposite diagonal, as in Figure 4, the second reduction again squares the slab, with the result that it has been spread in both directions.

By repeating this operation several times, it is



Method of rolling plates.

obvious that the slab will ultimately be drawn out so that what was originally the narrow dimension will now be sufficient to produce the required width of plate, and that by thereafter entering this side parallel to the roll axis, the plate may be increased to any desired length by successive reductions in thickness.

In actual plate rolling, a combination of the various methods of entry described above is always used, and it is quite evident that a high degree of skill is required to determine the proper combination of passes and entry angles to produce the desired plate in the minimum time and with minimum trimming losses.

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Types of Mills.

The original plate mills were two high continuous running, and after each pass the plate was returned idle over the top roll. This practice involved a great amount of labor and such heat losses as made the rolling of thin plates very difficult and expensive. An advance was made when the rolls were driven by a reversing engine, and this type of mill is now standard European practice, but there are objections to the two high reversing mill, in that the reversing engine is not economical and is very expensive.

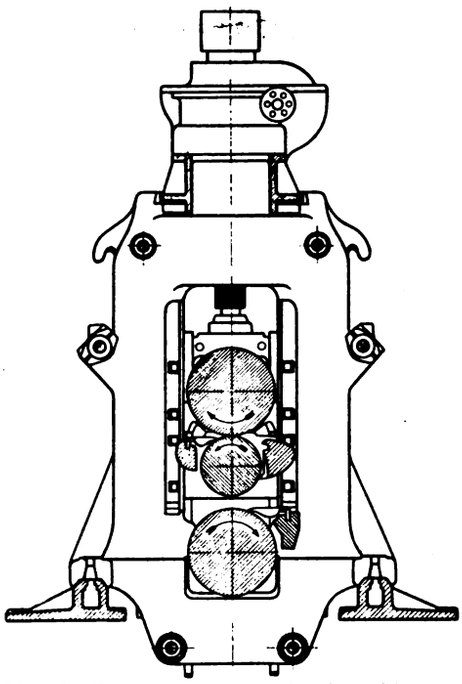

Fig. 5.—Lauth type of mill, in which plates are rolled almost exclusively in this country.

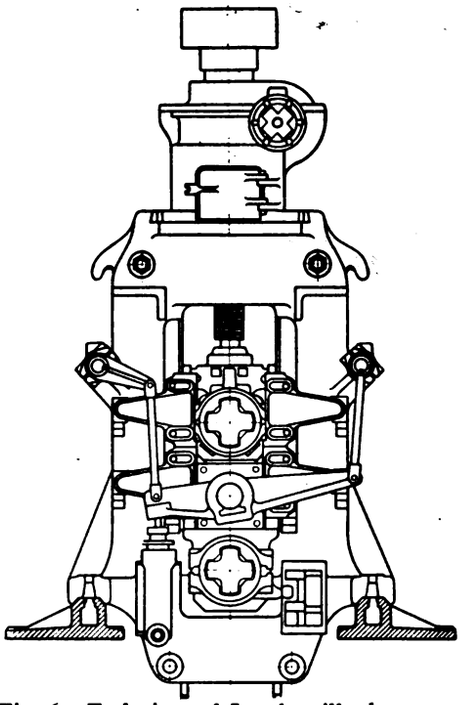

Fig. 6.—End view of Lauth mill, showing balancing of top roll and hydraulic operation of middle roll.

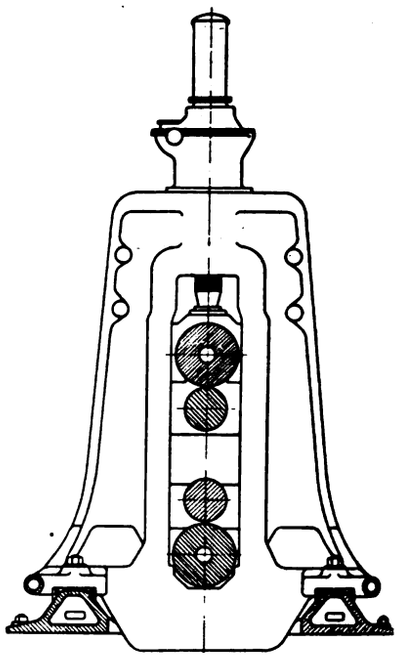

Fig. 7.—New 204" reversing plate mill being built by the United Engineering & Foundry Company.

In America, plates are now rolled almost exclusively on the mill invented by B. C. Lauth, shown diagrammatically in Figure 5, in which the top and bottom rolls are driven in the same direction, and the middle roll, which is much smaller in diameter, is rotated by friction as it is successively forced against the top and bottom rolls by the rolling pressure. This mill has the advantage of the three high mill in requiring only a continuous drive, and the added advantage that the middle roll being always supported by either the top or bottom roll, may be made of small diameter so as to greatly reduce the rolling pressure and the power required to operate the mill. Figure 6 shows a typical end view of a Lauth plate mill. The top roll is held firmly against the housing screw by counterweights, and the middle roll is pressed against the top or bottom roll as may be required by operating the hydraulic cylinder shown on the side of the housing. As a general rule the diameter of the middle roll is about two-thirds that of the top and bottom rolls.

At the present time, the United Engineering & Foundry Company is building a new type of plate mill in which two relatively small middle rolls are backed up by very large top and bottom rolls, as shown in Figure 7. In this mill the reversing drive has been reverted to, and the plate is rolled back and forth between the two middle rolls.

This design is used because of the great width of plate to be rolled, the roll bodies being 204 in. long, which in the Lauth type of mill would have required chilled rolls about 54 in. in diameter. Such large chilled rolls are beyond the present capacity of any roll maker, and also the power required to operate them would have been excessive.

The four high design adopted permits the use of 34 in. chilled rolls with 50 in. cast steel backing rolls. For mills up to 160 in. the Lauth type is feasible and is to be preferred to all others.

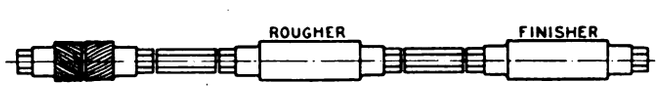

Fig. 8.—European arrangement of mills, showing one stand for roughing and another for finishing.

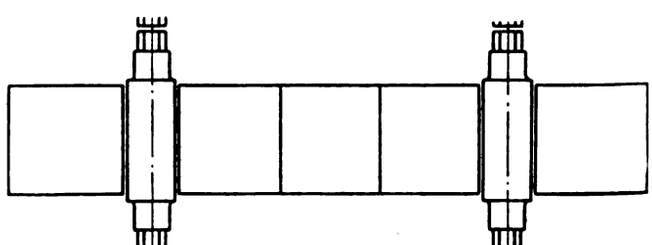

Fig. 9.—Arrangement of tandem mill, each roll stand being separately driven.

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Combination Mills.

The general practice in this country is to finish sheared plates from either ingots or slabs on one stand of rolls, and this is made practicable by the high quality of the chilled rolls which roll makers have developed. In Europe the practice is to use one stand for roughing and another for finishing, the roughing rolls being usually of sand iron and the finishers of either sand iron, forged steel or recently of chilled iron.

The European practice of using two stands is due to the quality of the rolls used, which will not maintain a smooth and even surface under combined roughing and finishing, and even with our chilled rolls it is advisable, when rolling large tonnages of thin plates, to use a separate finishing stand. The English and European mills are arranged as shown in Figure 8, and are almost all two high, but a similar arrangement with three high rolls can obviously be used, and in fact is used in America for rolling jobbing sheets and light plates. With the arrangement of Figure 8, one crew usually operates both mills, breaking the slab down on the rougher and then transferring it to the finisher, in which case the tonnage produced is little more than with a single mill. If two crews are used on this type of mill, only plates of medium quality can be made, as the irregular action of the rougher prevents smooth action of the finisher, so that the plates are not of uniform gauge and usually show marks due to the unsteady motion of the rolls.

The best solution of the light plate rolling problem is by the use of the tandem mill shown in Figure 9, in which each stand of rolls are separately driven, and the two stands are connected by tables, so that when roughing is completed, the plate is quickly delivered to the finishing stand. With this arrangement the mills are entirely independent, and can be so operated as to produce a tonnage about equal to two ordinary mills. In fact, the possible tonnage would seem to be in excess of two single stand mills in that it is possible to run the finisher at a higher speed than would be possible for roughing, and that the work can readily be distributed so as to balonce the time cycles of the two mills.

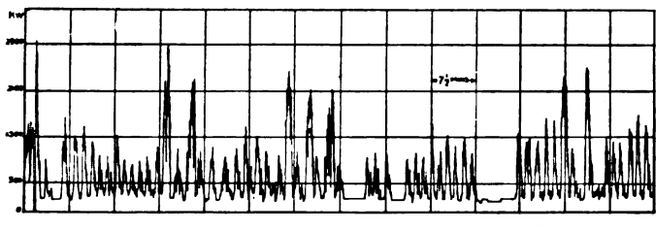

Fig. 10.—Typical plate mill power input chart.

Production.

The tonnage which a plate mill can produce will obviously depend greatly upon the average thickness of plate rolled, also to some extent upon the average width and length. The initial condition of the steel, whether ingot or slab, will make a great difference in tonnage. The quality of finish and the frequency with which it is necessary to change from one size to another will also have their effect. A mill rolling skelp in large orders of a single size from a suitable slab, will produce a much greater tonnage than the same mill rolling thick and thin, wide and narrow plates and changing frequently from one to the other, even though the average thickness be considerably greater in the latter case.

As the particular kinds and sizes of plate which a projected mill will roll are seldom known, it is clearly impossible to predict in any case the exact tonnage which may be expected, but an average of actual results from most of the well-known mills in this country after segregating the mills according to the class of plates constituting their principal tonnage has been compiled. The following table gives the average thus obtained.

Monthly production of Plate Mills in tons of 2240 lbs.—Good average practice

1 Mill Width Inches	2 Light Plates 12 gauge to 6 gauge Average about 8 gauge		3 Medium Plates 8 gauge to ½" thick—Average about 5/16"		4 Heavy Plates ⅜" to 2" thick Average about ¾"		5 Actual average production. Best practice on existing mills.	
	Rolling from		Rolling from		Rolling from		Rolling from	
	Slabs	Ingots	Slabs	Ingots	Slabs	Ingots	Slabs	Ingots
72"	5400	....	8000	....	9000	....	7500	.....
84"	6500	....	9500	....	10500	....	9800	.....
90"	6800	....	10000	....	11200	....	13000	.....
110"	8300	4500	12200	....	13700	....	.....	.....
128"	9800	5000	14500	7000	16200	9700	17500	.....
132"	....	....	15000	7200	17000	10200	.....	.....
140"	....	....	16000	7600	18000	10800	18000	10000
152"	....	....	17500	8400	19500	12000	.....	11000

It will be observed that in column 5, the "best actual practice on existing mills" is, in some cases, less than the probable tonnage given in the preceding columns. This is explained by the fact that in these particular widths no existing mill is known where the practice is thoroughly good.

Power Requirements.

There is probably no plate mill in existence in which the driving power is not the measure of the possible reduction—that is to say, the rolls, spindles, pinions, and the steel itself will stand greater strain than the drive can supply, and this condition is not likely to change, because excessive reductions rapidly increase the wear of rolls and tend to produce plates with thin edges and thick centers. This is equivalent to saying that the limitations of the mill first appear in the durability and spring of the rolls so that beyond certain limits additional power cannot be used. It is, therefore, of little value to make complicated calculations to determine the size of drive, and of great value to compare the various mills in successful operation and thereby obtain an empirical proportion of power to mill.

In all existing plate mills there are only slight va-

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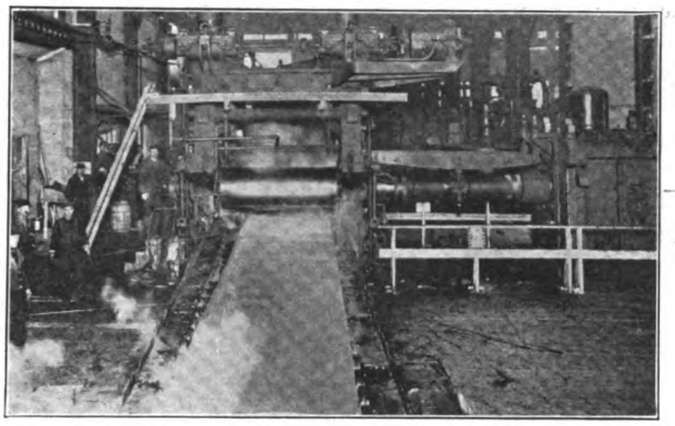
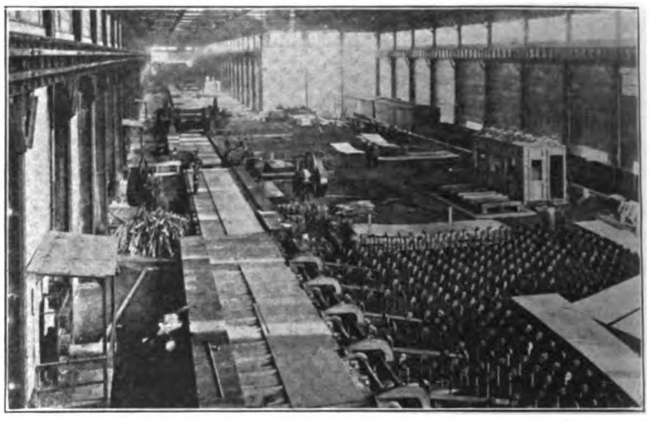


View of 90" plate mill at the Inland Steel Company—The plate, which is nearly finished is seen on the table, just at the end of a pass.



Typical view of a plate mill looking from the finishing end. The cooling beds are seen at the right—The mill proper is in the extreme background.

riations in the ratio of length to diameter of roll and the speed of rolling is uniform within limits of about 10 per cent from the mean so that if we compare the power requirements on the basis of the inch width of maximum plate per 100 feet peripheral speed of rolls we shall be correct within practical limits.

A comparison of 16 mills on the above basis gives the following results:

	Normal or economical H. P. per inch width of maximum plate for 100 ft. surface speed of rolls	Peak load which drive can sustain for periods of ½ minute at intervals of about 2 minutes per inch width of maximum plate per 100 ft. surface speed of rolls.
Average of 16 mills	5.37	8.85
Maximum individual mill	9.70	13.90
Mill producing the maximum tonnage per month per inch width.	4.42	7.11
Average of 5 mills producing exceptionally large tonnage per month per inch width.	5.54	9.92

As all mills of the type we are discussing are equipped with flywheels the diagram, Figure 10, will represent in a general way the input of power required from the drive, from which it is evident that both the normal power and the peak power of the drive are factors to be taken into account in such a comparison as is outlined above.

It will be noted that while five of the best producing mills in the country averaged 5.54 h. p. per inch, the particular mill which produced the best tonnage had only 4.42 h. p. or fully 20 per cent below the average. A careful study of all the data at hand leads us to the conclusion that there is nothing to be gained by providing normal power in excess of 6 h. p. and a peak of 12 h. p. per inch width of maximum plate per 100 feet surface speed per minute. In computing this data, the following plate widths have been assumed as maximum for the various mills:

Mill Width	Maximum Plate Width
72 in.	64 in.
84 in.	76 in.
90 in.	80 in.
110 in.	98 in.
132 in.	120 in.
140 in.	128 in.

The surface speeds of the various mills range from 370 to 500 feet per minute and average about 450 feet. The best producing mills runs at 420 feet.

From the preceding it is evident that neither extreme power nor speed are essential to large production, which depends more on the handling facilities.

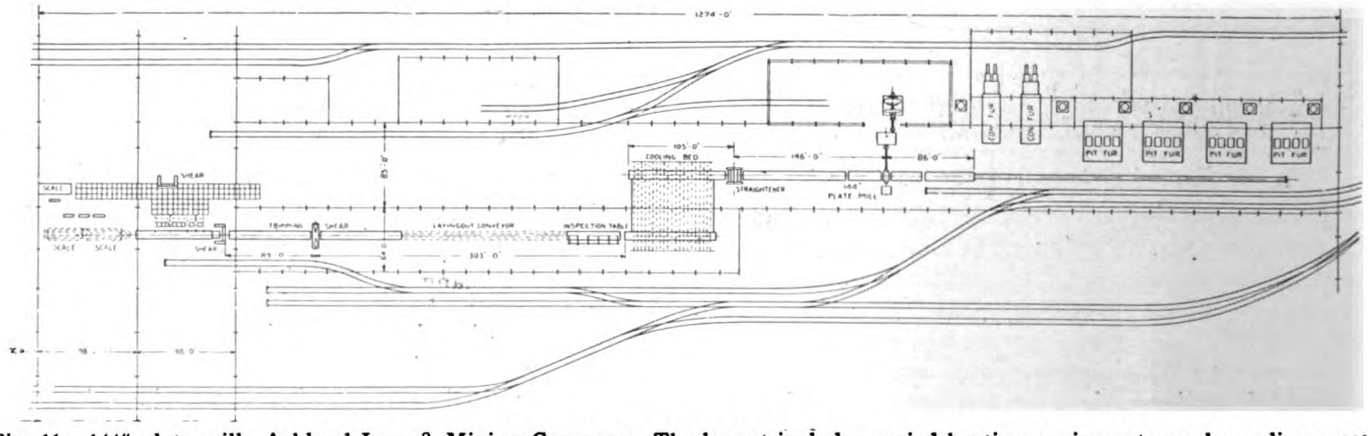


Fig. 11.—144" plate mill—Ashland Iron & Mining Company—The layout includes varied heating equipment, ample cooling space for medium plates, with space for additional beds if required for heavy work, a convenient laying out conveyor, good arrangement of shears with space for additional shearing equipment and liberal storage space.

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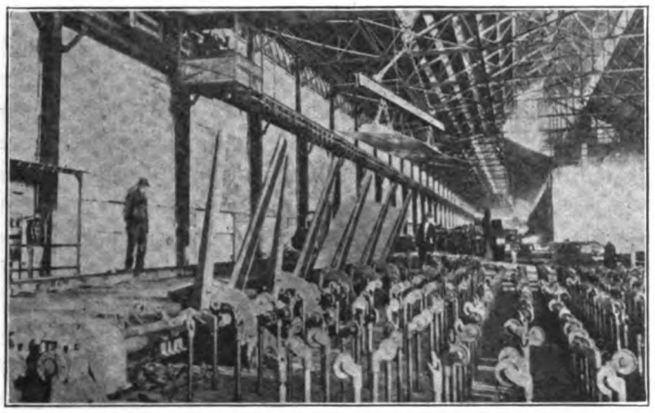
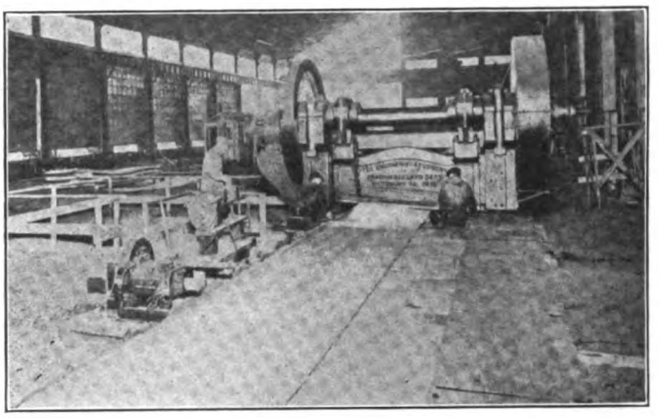


The inspection table arranged with arms which raise the plate for examination on the lower side and the "Castor Bed," on which the plate is handled for shearing and shipping.



Laying out and shearing the plates—Proper facilities for these operations are of great importance in reducing the scrap losses and increasing the production of the mill.

combined with a judicious distribution of orders so as to use each mill to its best advantage.

Heating.

Where a plate mill rolls from an ingot, it is necessary to install soaking pits for large sized ingots, and if there is no available source of slabs for light plates, either side door or continuous furnaces are necessary for the small ingots. If the mill works from slabs, the continuous furnace is thoroughly practical and has great advantages in fuel economy and convenient handling of material.

The nature of the product has considerable influence in deciding the heating equipment, but in general large mills (100 in. and over) should have both soaking pits and continuous furnaces if ingots only are to be rolled, or side door and continuous furnaces if the rolling is all from slabs. The installation of side door furnaces is necessary on these mills when rolling entirely from slabs, because a few very large slabs will sometimes be required which cannot easily be handled in the continuous furnaces.

A good equipment for a large mill for general service, would consist of two four-hole pits and two continuous furnaces, as the rolling schedule can usually be arranged to draw intermittently from the pits and thus make both heating equipments available at the some time. An occasional mill may be laid out for a specific purpose requiring only slight variation in slab or ingot sizes in which obviously only one type of furnace will be used. For the narrower mills (100 in. or less) three continuous furnaces give thoroughly good facilities, and where the tonnage is not to be forced to the limit, two furnaces will be sufficient.

Arrangement of Plant.

After rolling, a plate must be leveled, cooled, inspected, marked, sheared, weighed, stored and shipped, and the means for performing all these operations will vary considerably depending upon the class of plates to be handled.

None of the plate mills now in operation are equally adapted to all classes of plate, as it frequently happens that the requirements are not definitely known when an installation is projected. The United Engineering & Foundry Company has developed a general purpose layout for the Ashland Iron & Mining Company, shown in Figure 11. The equipment shown is the initial installation, which will be thoroughly good for plates up to about 5/8 in. in thickness and will be able to make occasional plates up to 2¼ in. in thickness, but provision has been made for additional

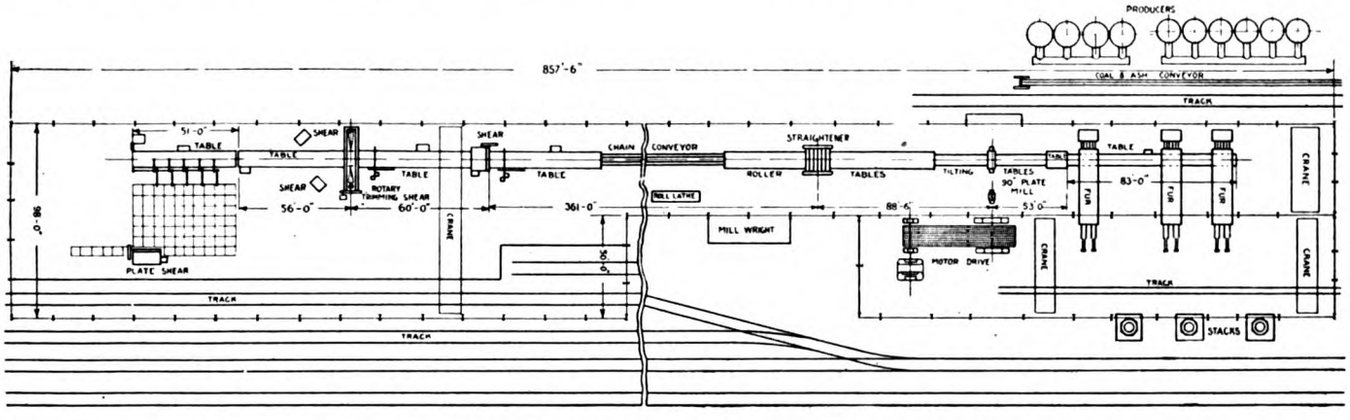


Fig. 12.—32" x 190" plate mill—Inland Steel Company—This mill was laid out for rolling car and tank plate—For ship plate and other heavy varieties, the cooling space provided by the chain conveyor is not quite sufficient, and for boiler plate or other kinds where inspection is rigid, the shearing capacity and storage rooms are too limited.

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equipment, which will make the mill equally suitable for all classes of plates. In other words, the initial installation is well adapted for the manufacture of car plate, skelp, structural plate and tank plate. Ship plate can also be conveniently made, although for a large tonnage of this class of plates which includes many irregular shapes, additional shearing equipment would be required. For boiler plate and other heavy kinds the cooling space will be deficient, and also the shearing capacity. Space has been provided according to a predetermined plan for additions to both the cooling space and shearing equipment so that the lighter plates will pass over only one-half of the cooling bed and thence to the light shears, while heavy plates will pass over the entire cooling bed and thence to suitable heavy shears. Another interesting installation is that of the Inland Steel Company, shown in Figure 12.

Storage Space.

An important factor in the operation of a plate mill is the warehouse. Plates cannot conveniently be piled to great depth, nor can they be stored on edge because of the difficulty of handling. In many cases the customers' inspection must be made in the warehouse, and this requires a large amount of room, as each plate must be lifted from a pile so that the inspector can examine the under side, and must then be placed in another pile if discarded, or loaded if accepted. In some cases, as when skelp is rolled for tube mills operated by the same company, it is possible to operate with very limited storage space, but for boiler plate and most other varieties liberal room is necessary.

The subject matter of this article, together with more complete data, has recently been issued by the United Engineering and Foundry Company in the form of a booklet describing their plate mills and auxiliary apparatus.

Rolling Mill Power Requirements

Investigation of Data Obtained from Tests on Three High and Reversing Mills—Influence of Various Factors on Power Requirements—Curves Showing Test Results.

By F. DENK,
Consulting Engineer, Pittsburgh, Pa.

Having shown in the previous article (August issue of The Blast Furnace and Steel Plant) that the formulae for calculating the power required to roll steel are not only theoretically incorrect, but hold good only for those cases where a vertical pressure is exerted in the passes, i. e., for blooming and billet mills.

We will now show in how far the writer's formula and that of Prof. Lang are identical. In order to make the identity of the two equations more apparent we will show in short how the two formulae have been determined.

Ordinarily the results of mill tests are plotted in the form of "pounds steam per ton of steel against elongation" or "horsepower-hours per ton of steel against elongation." (See Fig. 1, which gives a general arrangement of such curves). The curves all show a more or less parabolic shape, and might, for this reason, be used for the calculation of the mill power, but only when the rolling conditions of the mill, for which the power is to be calculated, are the same as for the mill on which the test had been made, and for which the curves have been plotted.

Attempts have been made to bring the horsepower-hours per ton into a single relation to the elongation, but this investigation had to be abandoned because these curves do not show the influence of temperature, roll radius, etc. The elongation is also not a single variation, but depends on several variable quantities, which may be seen from the following derivation:

$$E = \frac{l}{L} \text{ or } \frac{A}{a}, \qquad (2)$$

where E = Elongation
l = length after pass
a = area after pass
L = original length of ingot
A = original area of ingot

Now the area after the pass is equal to the product = h× w (height after pass × width after pass).

But the height after the pass is equal to the height before the pass minus the draft, which gives,

$$a = (H - d)\, w.$$

This inserted into equation (2) gives

$$E = \frac{A}{(H-d)\, w}$$

The only constant in this equation is "A," the original area. The height before the pass "H", the draft "d" and the width after the pass "w" are quantities, varying for each pass. The derivation, however, suggested the uses of one of these variable quantities, and the natural one to apply seemed to be the draft "d", because, for a certain reduction in height there must be a certain amount of work done. Attempts were therefore made to obtain a simple relation between HP-sec's/cu. in. displaced volume and the draft.

Careful investigation into the test data obtained from a reversing blooming mill showed that it is possible to bring "power required" and "draft" into a

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simple relation. Three ingots were at disposal. The rolling schedule for the mill in question is such that all the passes, except the last one, are rolled in two grooves, with a mean radius of (approximately) 12¾ in. and 12½ in. (The last pass is not considered here, inasmuch as it would only be represented by one point in each case). In order to investigate the relation mentioned above, the horsepower-seconds per cu. in. of displaced volume were plotted against the draft (see Fig. 2). The points corresponding to the same roll radius were connected with each other, as shown in the curves on the left of Fig. 2, the letters "A_1, A_2", "B_1, B_2" nd C_1, C_2" representing data from three different ingots. The full lines are nearly straight, and might as well be connected by straight lines, but when it is considered that for d = o, the work done must be = O, we see that the connecting lines cannot be anything else but curves.

We have now a relation between the draft and the

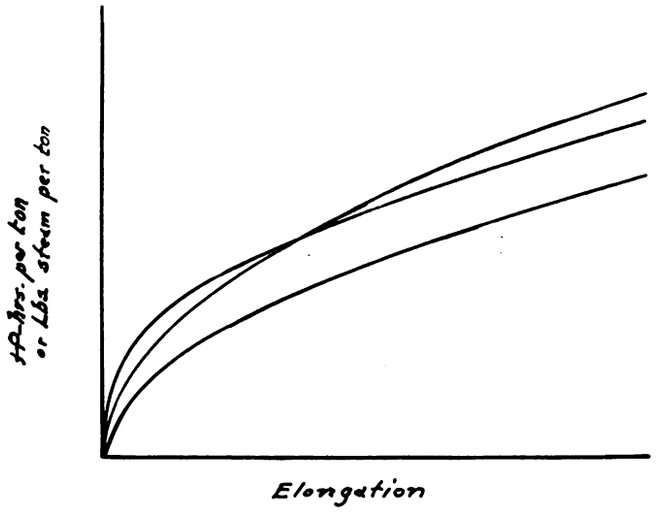

Fig. 1.—H.P. hrs. per ton or lbs. steam per ton plotted against elongation.

HP-sec's/cu. in. within certain limits, but none of which hold good for the whole ingot. Attempts were made to obtain such a relation by reducing the different values to a common base, in this case to a radius of one foot. Since many authorities on mill power state, that the power required to roll steel is directly proportional—not to the radius, but—to the square root of the radius, this reduction was carried out by dividing the different values by $\sqrt{R}$. After the division the points thus obtained were plotted, and those belonging to one ingot were connected by smooth lines, which are shown on the right of Fig. 2 Thus, all values, belonging to one ingot, can be connected by one smooth curve, after reducing them to a radius of one foot. The curves also show the influence of the temperature. The lowest power is required for curve "C", having an average rolling temperature of 2,010 deg. F., while curve "A" shows the highest power consumption for an average rolling temperature of 1,870 deg. F. Curve "B" lies somewhat below the mean of the two other ones; this shows that the average rolling temperature should be somewhat higher than the average of curves "A" and "C", which is 1,940 deg. F. The mean rolling temperature of curve "B" is 1,960 deg. F.

As long as the investigations were carried through by means of data obtained from tests on reversing mills, little trouble was experienced to get the data in line and plot the average curves, which were reasonably correct.

On three-high mills, however, the establishment of the relation is much more difficult than on reversing mills. In the first place, there are only a limited number of passes at our disposal, secondly, there is a larger drop in the rolling temperature. While on a reversing mill the average temperature of an ingot differs only a few degrees from the highest and lowest temperature during the rolling period, (with the exception, when a slab is rolled which offers a large cooling surface to the air) there is a large difference, when rolling an ingot in a three-high mill. This difference may become as high as 150 deg. to

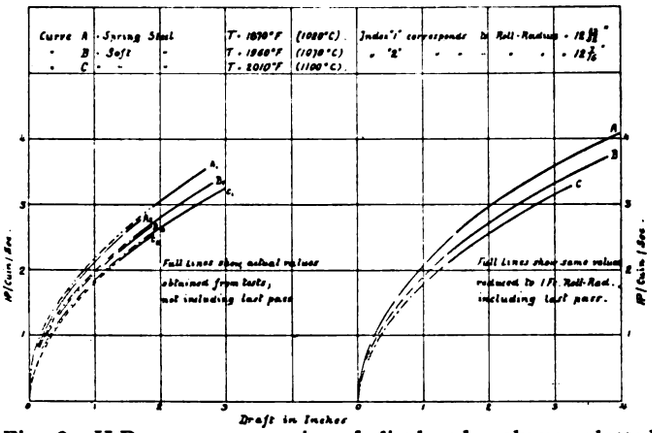

Fig. 2.—H.P. secs. per cu. in. of displaced volume plotted against draft.

200 deg. between the highest and lowest temperatures, which naturally, influences the amount of power necessary to roll the steel. Fig. 3 shows two curves, one, "A", representing a bloom rolled to a 8 in. by 7¾ in. section in nine passes, and the other one, "B", rolling a bloom to a 9½ in. by 9½ in section in seven passes, both rolled on three-high mills. As a base for the theoretical calculation, in case of curve "A" a draft d = 3¾ in. was taken, this being the draft for the fifth pass, i. e., in the middle of the rolling period. All the passes before the fifth are lower, while those after the fifth are higher than they should be theoretically.

For instance, in curve "A", point "d", 2 in. draft, represents the last pass and lies high above its theoretical place at "d_1"; point "c", 2½ in. draft, representing the eighth pass, is also higher than it should be, although not so far off as "d"; it lies at "c_1". Point "b", 2½ in. draft, represents passes rolled during the first half of the rolling period; it is therefore,

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at "b_1" which is lower than it should be theoretically. Finally point "a", representing 4 in. draft, occurs before and after pass 5. The influence of the higher temperature at the beginning of the rolling is partly offset by that of the colder one toward the end of the rolling, and, therefore, point "a_1" is only a little below its theoretical point "a".

The same reasoning may be applied to curve "B", showing values for a bloom rolled to a 9½ in. by 9½ in. section in 7 passes. The only exception here is, that, on account of the smaller number of passes, and, therefore, the smaller variation in drafts, the influence of the temperature can more easily be distinguished. For a draft of 2½ in., for instance, three points can be seen, viz.: "m_1", "m_2" and "m", the latter representing the passes during the middle period of rolling, while "m_1" represents those at the end, and "m_2" those at the beginning. Point "1" 3 in. draft, is the first pass, and lies at "1_1", below its theoretical point, point o, 3½ in. draft occurs during the mid-

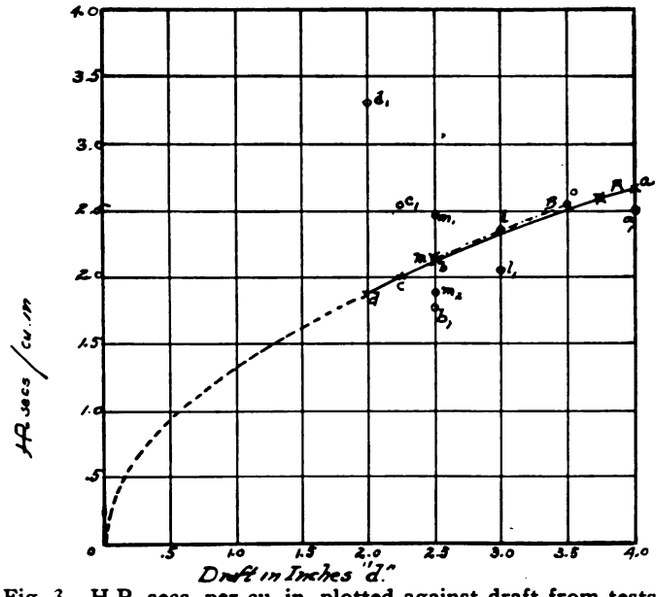

Fig. 3.—H.P. secs. per cu. in. plotted against draft from tests taken on three-high mill.

dle of the rolling period; it, therefore, lies on the curve.

Exceptions prove the rule, therefore the curves for the three-high mills with all the deviations show the correctness of our formula, since each and every one of these deviations can be traced back to its origin.

Thus far a relation between the power required and the temperature, the draft and the roll radius has been established. In a similar way it can be shown that this power depends also on the weight of the ingot and the speed of the rolls. The last-mentioned relation, however, holds only good from a certain limit upward, as was stated in last month's article. Both these relations, viz.: the influence of the weight of the ingot and of the speed of the rolls on the power requirements, will be dealt with later in connection with the explanation of Prof. Lang's formula.

The influence of the rolling temperature upon the power required may be seen from Fig. 4, which shows the relation of these two items to each other for different drafts. All values are reduced at an ingot-weight of one ton and a roll-radius of one foot, in order to make them comparable. The difference in rolling speed has in this case been neglected, since all the data for plotting the curves were taken from tests on mills, which were working with practically the same speed. The small discrepancies shown be-

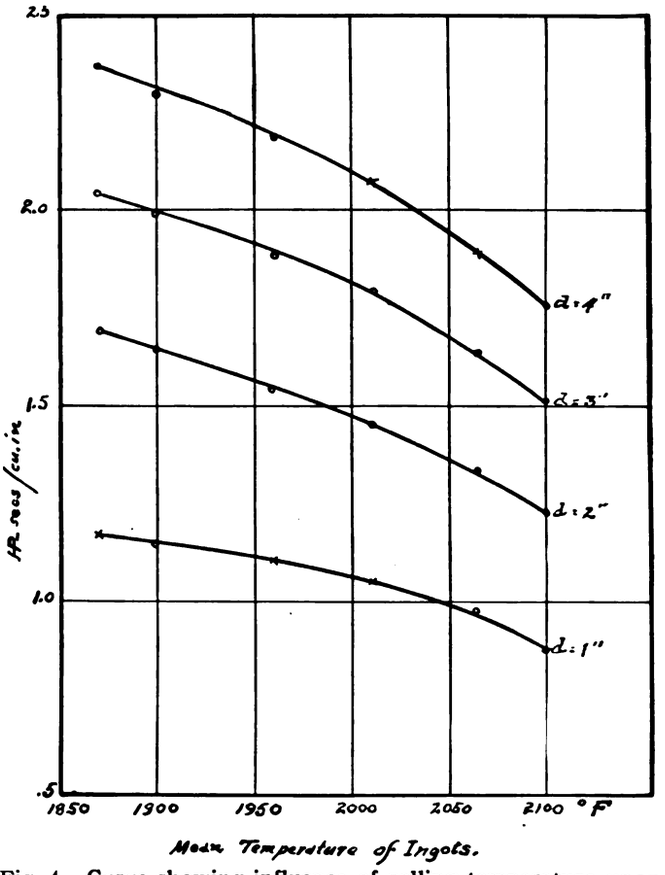

Fig. 4.—Curve showing influence of rolling temperature upon power requirement.

tween the points marked and the average curves on Fig. 4 may be due to this omission.

When using the equation:

$$A = C\sqrt{\frac{d \times R \times W}{S}} \qquad (1)$$

where

A = power required to remove one cu. in. of material at any draft "d", any roll radius "R", any ingot weight "W" and rolling speed "S";

C = power required to remove one cu. in. of material at a draft d = 1 in., a roll radius, R = 1 ft., an ingot weight, W = 1 ton and a rolling speed S = 1 R. P. S., for the calculation of a rolling mill, the factor "C" can be taken from the curve for d = 1 in. in Fig. 4. This curve gives the factor "C" directly between the limits of about 1,870 deg. F. to 2,100 deg. F. It can easily be elongated beyond these limits to 1,850 deg.

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and 2,150 deg., and thus covers practically the whole range of the rolling temperature.

It must be kept in mind that equation (1) is an empirical one, derived by carefully separating and dissecting data obtained from actual tests made in the United States, in Canada and abroad on three-high and on reversing rolling mills, steam driven as well as electrically driven, not by developing some theory on the rolling process or on the flow of steel under certain conditions. The formula may, for this reason, be easily attacked from a purely theoretical standpoint. But it should not be forgotten that it eliminates practically all guesswork, which was connected with calculations of mill power, with the exception of that which never can or will be eliminated, that is the guessing of the amount of work lost due to false bites, roll slips and the like, and last, but not least, the guessing of the amount of work lost due to the "personal equation."

In the next article we will give a short derivation of Prof. Lang's equation, and will show the close identity of this formula and formula (1), which was developed in the August issue of The Blast Furnace and Steel Plant.

Characteristics of Roller Bearings

Comparison of Solid and Flexible Roller Bearings—Tests Showing Deformation Before and After Load Is Applied—Chart Showing Relation of Brinell Number, Scleroscope and Tensile Strength.

By P. B. LIEBERMANN,
Chief Engineer, Hyatt Roller Bearing Company.

The general idea of flexibility varies between the stiffness of a solid roller and the softness of a couch spring. If as stiff as a solid roller what would be the use and advantage of a spiral roller? If like a couch spring this would be an argument of the greatest danger. Actually there exists a flexibility somewhere between the two extremes. This flexibility is of a microscopical nature and yet of sufficient magnitude to give the spiral roller the advantage over the solid roller. This microscopical flexibility is of the same order as the thickness of the oil film in a plain bearing which measures between .0002 in. — .002 in., depending on the viscosity of the oil, temperature, speed, load and perfectness of lubrication. Nobody ever found fault with a plain bearing on account of a change in the thickness of its oil film under different loads and speeds. Likewise, the flexibility of a flexible roller is not of sufficient magnitude to disturb the precision of any machine in the least. The cushion effect is always there although the deflections are of microscopical size.

The following discussion, I hope, will make this entirely clear. By flexibility in the spiral roller bearing is meant the elastic deformation under load of the rollers and, to lesser extent, of the running surfaces in contact with the rollers.

Flexibility enlarges the theoretical "line" contact to a surface contact, and thereby reduces the contact pressure per unit of area. Lower contact pressure means reduced wear and increased life.

In solid roller bearings a certain amount of elastic deformation take splace too, but this is very small because the solid rollers in these bearings must be intensely hard to operate successfully. In the flexible bearings it is permissible to allow a considerably greater elastic deformation, due to the peculiar construction of the rollers.

Responsible for their flexibility and long life are: The materials used for the rollers, their grade of hardness, the arrangements of the fiber in the rollers to the fiber in the running surfaces, which are at right angles to each other, the hollow construction, the spiral construction, the large diameter of the rollers and the respective thickness of the walls.

Service has shown that intense hardness is all right for ideal conditions—that is, for conditions of uniform loads and medium pressures. But inasmuch as shocks, vibrations and overloads are present in the majority of cases, it can easily be seen that an elastic or flexible bearing is the logical answer for such cases. It should be remembered that all the elastic deformations constituting flexibility are microscopical, that is, they cannot be noticed with the bare eye, or even with ordinary measuring instruments, nor do they leave an impression from which to judge their magnitude as long as the pressures do not exceed the elastic limits.

To deliver an actual, that is, a visible proof of the flexibility claimed for the flexible roller bearings, the following arrangement was selected: A steel plate of the same hardness as the inner races was coated with a thin film of a softer metal, copper deposited by electroplating. On this plate were placed successively a flexible roller, a solid roller, and the same pressure was applied to each in a testing machine. The copper coating retained a record of the area of contact in each case, just like a finger print on a piece of sealing wax. The rollers were of the same diameter: ⅞ in., and belonged to bearings of the same rated load capacity: about 3,000-3,500 pounds. The rollers were $2\,^{5}/_{16}$ in. long

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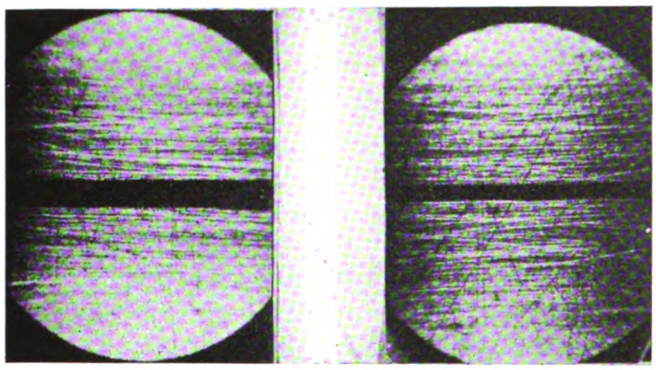
In order to obtain a plainly visible record, a pressure of 3,000 pounds was used for the test. This pressure represents the full load capacity of the whole bearing applied to a single rolling element.

An enlarged microphotograph of the records was taken and Figure 1 shows plainly that the flexible roller has produced a record twice as wide as the solid roller. In other words, this test furnishes the proof that due to its peculiar construction and the resulting flexibility, the flexible roller has a contact area which is 100 per cent larger than that of a solid roller of the same diameter and length.

The width record was supplemented by a test measuring the depth of contact. For this purpose a device of extreme sensitiveness was specially designed and it was so applied as to measure the deformations under load. Figures 2, 3 and 4 show that the impression produced by a solid roller under load is twice as sharp and about 30 per cent deper than the one made



Flexible Roller. Solid Roller.

Fig. 1.—Microphotograph of contact records, showing comparison of contact area of flexible and solid rollers.

by the flexible roller after removing the load, while the solid roller left behind a slight permanent deformation of the dimensions shown on the plate. All of this means that the life and wear of a flexible bearing, due to its inherent design, should be considerably higher than the one of a solid roller bearing of the same size and rating, which is actually borne out in practice.

Other advantages of flexibility, such as its property to follow irregularities of the running surfaces, its property to reduce friction and wear, etc., are fully covered by the classic friction test of the Franklin Institute, of the State of Pennsylvania, made in 1898.

Hardness.

A discussion of friction and flexibility is not complete without saying a few words about hardness.

In any anti-friction bearing the surfaces in contact must be of considerable hardness in order to properly withstand the enormous contact pressures. The flexible bearing does not have to be as hard as a solid roller, and it therefore withstands shocks and vibrations without suffering increased wear, or increased friction. It is only when running a bushing directly in a shaft or axle that the engineer will be face to face with hardness requirements. It is well enough to specify cold rolled steel and to lay down a certain chemical analysis for shaft or axle steel and to call for, say .45-.50 per cent carbon and as much manganese as possible. But a more reliable way of specifying steel and one that is a check on the analysis at the same time, is that of hardness number. Cold rolled steel is only too often nothing but polished hot rolled steel, or in the smaller sizes it is screw stock. The latter is an extremely mild steel with insignificant carbon content and should never be used in direct connection with a flexible bearing. We have found through years of experience that for line shaft work cold rolled steel, (the real article) of 200 Brinell hardness will easily stand 75 pounds per square inch continuously, while in ordinary cases with steel of doubtful character we cannot afford to run over 40

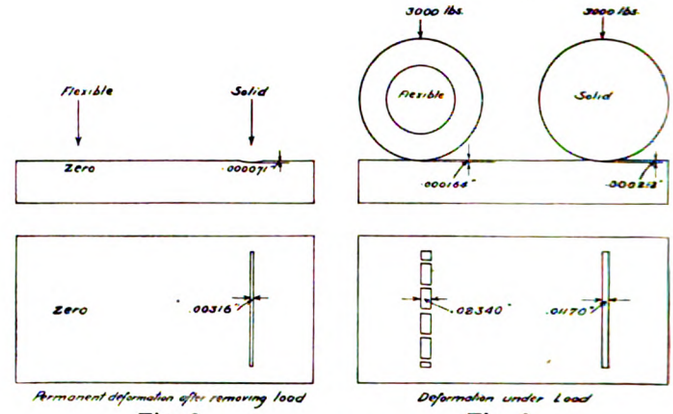


Fig. 2. Fig. 3.

Deformation produced by flexible and solid bearings during and after load is applied.

pounds per square inch. In mine car service we found cold rolled axles of 200-225 Brinell hardness to stand up under pressures of up to 125 pounds per square inch. For higher loads heat treated axles were found to be necessary.

It is obvious that with any application the softest part is the weakest link in the chain, and therefore with a soft shaft a bearing can be operated only at a fraction of the load for which it was designed. It is customary to designate hardness either by Brinell number or by scleroscope number. The Brinell instrument measures the impression of a steel ball of standard size under standard load, into the piece to be tested. It is then

$$\text{Brinell No.} = \frac{\text{Pressure on ball in kg.}}{\text{Area of indentation surface in sq. mm.}}$$

In this test the diameter of the steel ball is 1 cm., the pressure on the ball is 3,000 kg., the area is determined by measuring the diameter of the indentation with a microscope and by reading off a table the corresponding hardness number. In the Shore scleroscope, hardness is indicated by the rebound of a small steel weight from the surface of the test piece. The

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weight is allowed to fall about 10 inches, and the distance it rebounds is taken as a measure of the hardness of the sample. A scale is provided which is divided into 140 equal parts and the hardness is expressed as the number on the scale to which the weight rebounds.

When specifying a certain hardness, say for instance, for car axles, we found that in some steel mills it is customary to use Brinell, while in others scleroscope hardness is used. Still in others nothing but the tensile strength is available. Although there does not exist a fixed relation between these three for all grades of steel an attempt has been made to place Brinnell number, scleroscope and the tensile strength on one chart so that one can be translated into the other without much trouble. Figure 5 illustrates the relation of the various items and it therefore can only show average figures. This should be remembered when using it.

On the chart are drawn two additional lines, one showing ductility and one showing safe permissible

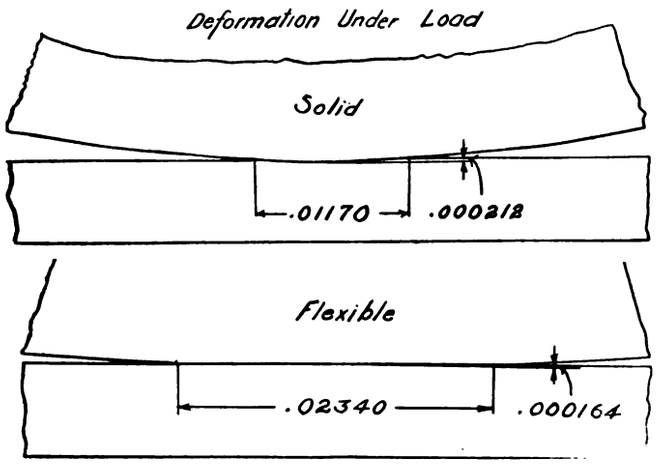

Fig. 4.—Deformation under load of solid and flexible bearings.

load in pounds per square inch. The line of ductility which also is a measure of brittleness or elongation, is drawn without scale and is merely meant to show that with increased hardness the ductility rapidly decreases. The ductility lines of different steels of different analysis are all separate lines, but parallel to each other and rather widely spaced. This is the reason why a single line without scale had to be shown, which is entirely sufficient for our purpose. The permissible load line, represents average conditions and some judgment has to be exercised when applying it to specific conditions. It is obvious that at low speeds and infrequent service higher loads are permissible, while at high speeds or severe service a reduction of load is advisable. The chart illustrates plainly that hardness increases with tensile strength and load capacity. This increase, however, is accomplished at the expense of ductility, which latter decreases rapidly with increased hardness.

The chart is useful for many purposes. For instance, when replacing plain bearings we are in many cases also replacing shafts or axles by substituting a better steel for a poor steel, often nothing but wrought iron. Wrought iron or ordinary steel has a Brinnell hardness of about 120 to 135, while .50 per cent cold rolled steel has a Brinell hardness of 200-220. A glance at the chart shows that we have increased the tensile strength from about 60,000 to about 120,000. In other words, the strength of the shaft has been increased 100 per cent, which in most cases may be entirely unnecessary. For obtaining the same strength that existed in the old shaft, a corresponding reduction in the diameter of the new shaft can be made, thereby reducing the size of the bearing and at the same time its cost.

Considerable progress has been made in the application of roller bearings to steel mill buggies, such as charging buggies, ingot buggies, ladle cars, cinder cars, slag cars, and others. In all of these cars there

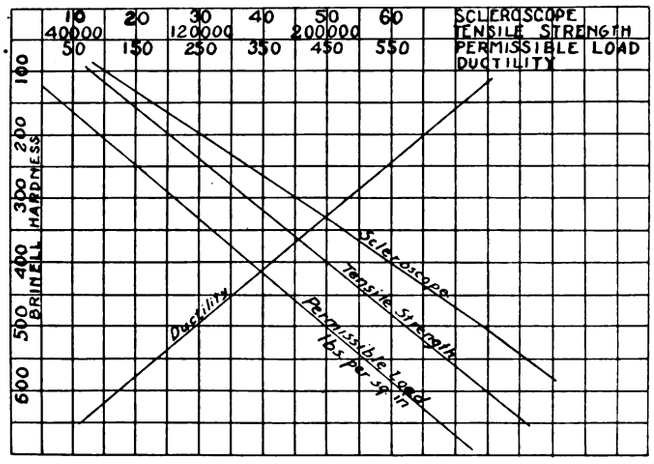

Fig. 5.—Relation of Brinell number, scleroscope and tensile strength, also shows ductility and safe permissible load.

exists a demand for a better bearing and the flexible roller bearing, after years of service has demonstrated its usefulness. In the June issue of The Blast Furnace and Steel Plant an article appeared which described tests made on these bearings by the Hyatt Roller Bearing Company, and their results. The results showed that in the case of cars used in steel mills that a larger number of cars can be pulled by the same locomotive if flexible roller bearings are substituted for plain bearings, and at the same time the speed can easily be doubled which means an all around speeding up of production without additional outlay for locomotives. The saving of power is particularly noticeable when storage battery locomotives are used.

When running up grade, as for instance to the charging floor of the open hearth furnaces, a correspondingly larger number of cars can also be pulled, depending on the percentage of grade and the draw bar pull of the locomotive.

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Greaves-Etchells Electric Furnace

English Furnace Recently Introduced in This Country—Uniform Product and Constant Circulation Secured by Convection Currents Set Up by Bottom Heating.

By ALFRED M. STAEHLE.

The growing popularity of electric steel during the past year is evidenced by the increasing number of new electric furnaces. The Greaves-Etchells furnace, which has been successful in the Sheffield district and other parts of England, has recently been introduced in this country by the Electric Furnace Construction Company, in Philadelphia.

The chief feature of this furnace is the method of heating the bath. Two phases of a three-phase low-tension supply are connected with the respective upper electrodes, while the third phase is connected to the bottom of the hearth. A considerable amount

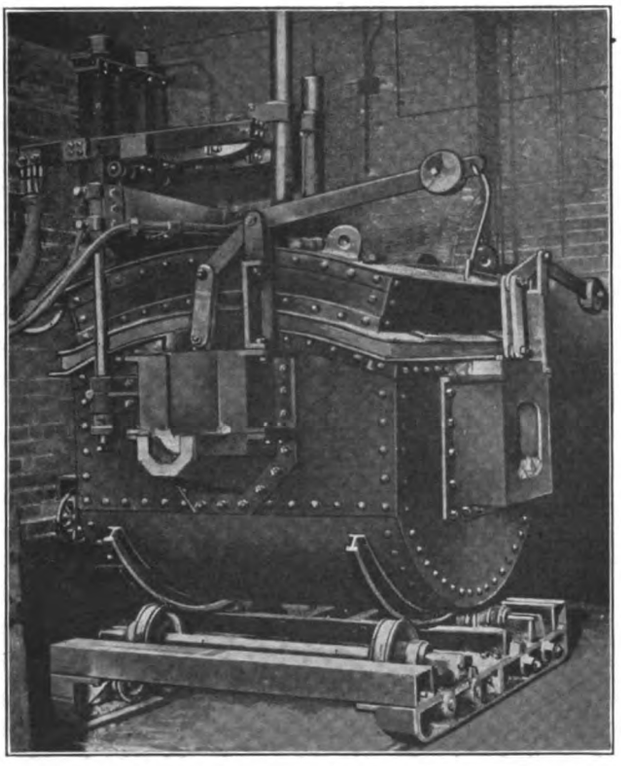

Fig. 1.—Greaves-Etchells electric furnace, showing compensating rollers and general construction.

of heat is thus generated directly underneath the bath, as well as above the bath. Constant circulation and a uniform product are secured by means of the convection currents set up by the bottom heating.

The Greaves-Etchells furnace is manufactured in sizes ranging from ½ ton to 30 tons capacity. The general construction of the furnace is shown in the accompanying illustration. Heavy boiler plate is used in the construction of the body, which is stiffened by angle sections. Two steel rails riveted on the bottom and resting on a system of compensating rollers constitute the tilting arrangement which is actuated by means of a screw, gear and motor. The necessity of continually adjusting the ladle is avoided by the compensating tilting arrangement which tilts the spout downward in a vertical line.

The roof, which is said to last 100 heats is made of silica brick resting in a steel frame, which in turn rests on the brick walls of the furnace. The design is such as to allow free expansion. The destructive action of the gases, causing the deterioration of the electrodes is somewhat minimized by the low roof. Insulated bronze or steel holders projecting from a wheeled carriage attach the electrodes to the steel jib. The carriage travels up and down on a vertical mast made of two channel sections bolted to the side of the body. Further economy of electrodes is affected by means of the annular water coolers on the roof. Raising or lowering the electrodes, which can be done either by automatic regulators or by hand, varies the energy supplied to the furnace.

The hearth is basic, 20 inches thick, consists mainly of dolomite, magnesite and tar, and is not penetrated

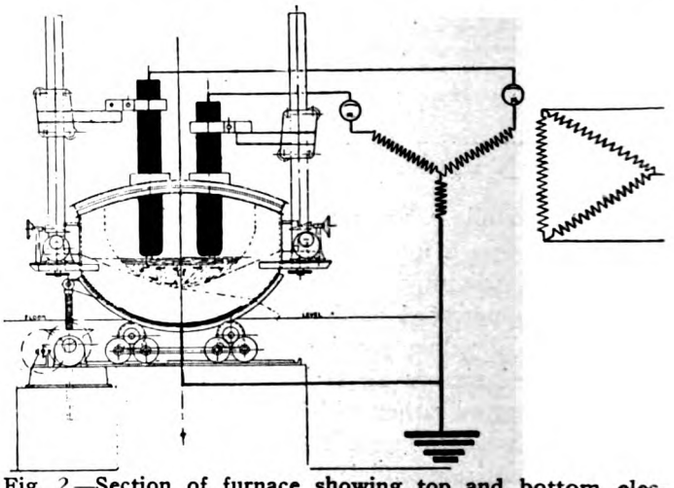

Fig. 2.—Section of furnace showing top and bottom electrodes and method of connecting.

by any water cooled studs or grids. It is constructed in such a manner that the electrical resistance is high at the inside of the bath lining, decreasing rapidly to a negligible quantity at the outside. The lining of a small furnace in England stood more than 1,500 heats of high-speed steel, with only one renewal.

The six-ton furnace is provided with a door and teeming spout on the casting-pit end, and two large charging doors, sealed after charging, on the sides of

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doors are swung open by a cranked lever, and when closed are held firmly by a steel wedge.

The connections are illustrated in Figure 2. The system of transformer ratios is so arranged as to give a perfect balance when the upper electrodes are in equal adjustment, and does not cause any out of balance load on the primary supply. The short circuit current of one electrode must traverse two transformers in series and in different phase, which automatically lowers the power factor momentarily and has a strong buffer effect. The fact that there is always a permanent return in the path of the current through the hearth also limits very considerably the effects of short circuits. The combination of these electrodes provides a most effective means for protecting the supply system from shock, while allowing a high power factor to be obtained on normal load, the furnace. The balanced doors of exceptionally good construction minimize the heat loss considerably. The usually averaging about 90 per cent.

The following furnaces have recently been sold: U. S. Government, for navy yards, three six-ton; American Radiator Company, one six-ton furnace; two 10-ton and one six-ton furnaces for Veehees, Spain, and two five-ton furnaces for Union Steel Corporation, of South Africa.

The advantages claimed for the Greaves-Etchells furnace are: a—The heat is generated above and below the bath. b—No cold bottoms. c—Circulation of the molten bath, which hastens refining of the metal. d—Sudden overloads are buffetted without the use of external reactances. e—The breaking of one arc does not affect the remaining ones. f—High power factor. g—No lateral adjustment of ladle.

Crystallization of Steel Ingots

Factors Influencing Crystallization of Ingots — Diagrammatic Representation of Formation of Structure — Effect of Reheating, Soaking and Rolling.

By J. F. KELLER,
Purdue University.

Iron and steel when in the solid state are of crystalline nature. The development of these crystals as the metal cools from the liquid state, depends upon two factors: First, the length of time required for the ingot to cool to the lowest point in the critical range and second, the impurities in the metal, particularly

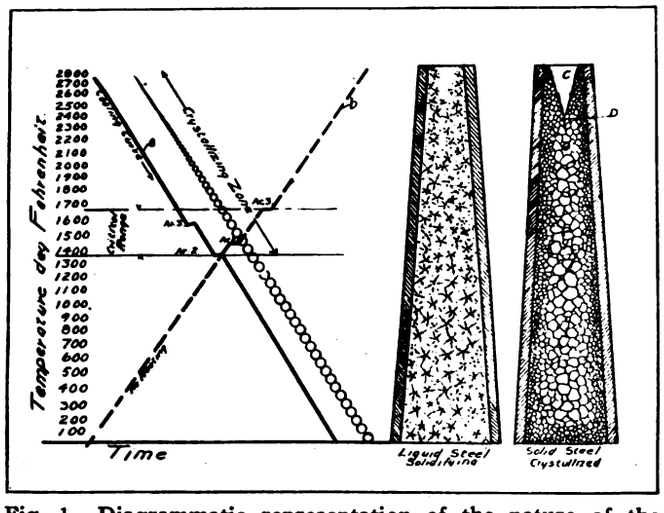

Fig. 1.—Diagrammatic representation of the nature of the formation of the crystalline structure in an ingot of slowly-cooled steel.

phosphorus or sulphur, both of which seem to act as catalytic agents and tend to increase the rate of crystal growth and this in proportion to their percentage in the metal. Most other alloying elements such as manganese, nickel, chromium and vanadium tend to retard this rate of growth to a more or less degree. Figure 1 is a diagrammatic representation of the nature of the formation of the crystalline structure in an ingot of steel.

Nucleus, represented by small dots in the figure marked "liquid steel," attract surrounding crystal matter proportional to the above mentioned elements in the metal, which may accelerate or retard crystallization, and the length of time the metal retains heat above the lowest point of the "critical range," is indicated by the line of circles parallel to the cooling curve. The circles also represent the relative size of the crystals. Therefore, the longer the metal remains in the crystallizing zone above the lowest point of the "critical range," the greater the crystal development, proportional to time, and elements in the metal, indicated by the "solid steel" ingot, Figure 1. The portion close to the mold solidifies and cools first, while the center of the ingot requires time to cool. Therefore the migration of the crystals are not prevented by the rigidity of the metal. The pipe end of the ingot, marked c, is, of course, defective, and should be cut off along the line D. Failure to do so will cause a serious defect in that portion of the finished product. Blow holes or gas pockets near the edges will cause seams, especially so in unweldable steels. In the lower grades of steel, the solidified ingot is placed in the furnace or soaking pit in order that the ingot may be uniformly heated to a semi-plastic state, first, to unite by welding all weldable imperfections or de-

Taken from paper read before the Steel Treating Research Society, March, 1917.

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fects in the steel, and second, the softer and more plastic the metal the less power required to move a given mass of material.

We now have the ingot in an indifferent crystalline state. Let us observe the effect of working the metal

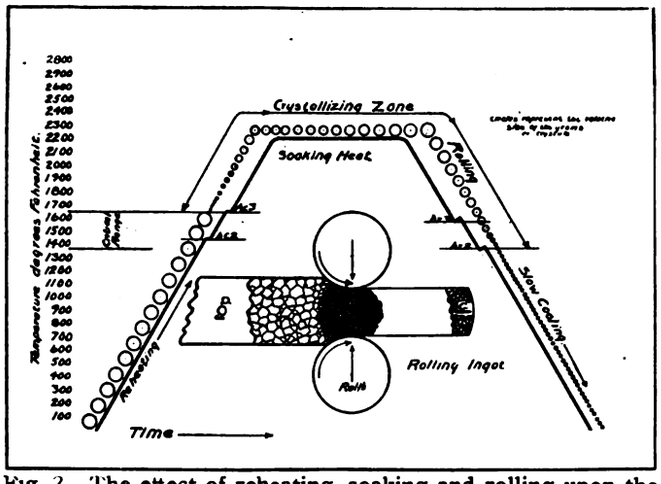

Fig. 2.—The effect of reheating, soaking and rolling upon the crystalline structure of steel.

such as reheating, rolling, hammering or squeezing. The reduction of the ingot has three objects in view: The formation into desired commercial shapes, elimination of defects in the case of weldable steel, and the reduction of the large sized crystals that were formed by excessive heating and slow cooling.

Figure 2 represents the effect of reheating, soaking and rolling upon the crystalline structure of steel. The line of circles parallel to the heating and cooling curve represents the relative size of the grains or crystals.

It may be noticed by following the reheating curve that the size of the crystals remains constant until Ac_3, the highest point of the "critical range," is reached, where a molecular change occurs, reducing the crystals to their normal size. The migration of crystals begins at this point into the metal and continues to develop proportional to the time and elements (the length of time the metal remains in the crystallizing zone). Continued rolling of the steel from a high temperature disturbs and prevents coalescence or migration of the crystals, indicated by the decrease in the size of the circles along the cooling curve and in the crystallizing zone to Ar_2 or Ar_1, or the lowest point of the "critical range." The above may also be observed in the figure "rolling ingot" where the portion of the ingot under compression between the rolls shows the grains or crystals very small, while on the end of the rolled bar, the crystals again coalesce proportional to the temperature above Ar_2. Therefore, if the steel is continuously rolled or hammered to the above point, the grain or crystal will be about normal size, while on the other hand, if work ceases above the point indicated, the structure will be proportional to the temperature at which work ceases and the elements contained in the metal being worked on. From the above, it would appear manifestly impossible to continue to roll or to hammer large sections of steel to the temperature indicated, owing to the enormous amount of power required to cause the steel to flow under pressure, while on the other hand, small sections requiring less power can be worked to the temperature desired, and sometimes below that point. This is one of the reasons for fine grains or crystals in small bars of commercial shapes.

Improving Blast Furnace Blowing Engines

Blowing Capacity of Existing Plants Increased by Installing Automatic Plate Valves—Methods of Rebuilding Blowing Engines. Reciprocating Engine Vs. Turbo-Blowers for Blast Furnaces.

After the general adoption of the steam turbine in large central power stations, the erroneous impression gained ground that the replacing of the reciprocating blowing engine by the turbo-blower could only be a question of a comparatively short time. This expectation of the uninitiated was not realized and it is doubtful if it will ever be realized.

The same laws of nature which give the steam turbine advantages over the steam engine, are obstacles in the case of the turbo-blower. Firstly, the steam turbine excels the steam engine only in the region below atmsophere, and in the compression of air for blast furnace use this region is absent, because, naturally the compression must start with atmospheric pressure. Secondly, the losses in the earlier or high pressure stages of the steam turbine are converted into heat which can be utilized in the latter stages, while in the turbo blower the losses in the early or low pressure stages mean additional work to be done in the latter stages. Thirdly, the steam turbine utilizes the highly efficient process of converting pressure into velocity, whereas, the turbo-blower tries to utilize the very inefficient process of converting velocity into pressure. Fourthly, the central power station utilizing large turbo generators, makes power for the sake of selling it. High steam pressure, superheat and vacua, which are impracticable around a blast furnace, can be introduced in the central station. Larger and larger units can also be installed, whereas, the size of the turbo blower is limited by the size of the blast furnace.

While for these very reasons engineers with

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knowledge of the underlying principles always had their doubts concerning general adoption of the turbo-blower, another, rather unexpceted reason has considerably delayed and hindered its introduction. The reason in question is, incorrect governing of the blower and consequent dusting of the furnace. The turbo-blower is a machine supposedly free from pulsations, and great advantages were expected from a steady stream of air going to the furnace. But practice has shown that, quite on the contrary, the vast majority of turbo-blowers vary in volume delivery a much greater amount than reciprocating blowing engines do. The amount of ore lost by dusting, due to this fluctuation of air supply is so great that most blast furnace managers are, at the present time, afraid to install turbo-blowers.

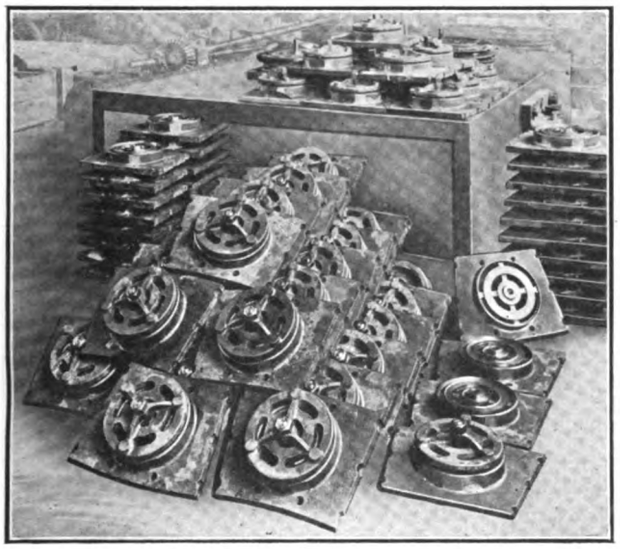

Fig. 1.—Valves made to fit a segmental arrangement of old valves.

In blowing engines the course of development likewise has been following rather unexpected lines. By comparison of the number of new furnaces built with the number of new blowing engines and new turbo-blowers installed, it is found that a comparatively small amount of new blowing equipment has been added. This surprising result is explained by the fact that a very large number of existing blowing engines have been rebuilt in such a way as to have a larger capacity and to serve a greater number of furnaces than heretofore. The possibility of increasing the capacity of existing blowing engines is largely due to the increase in piston speeds made possible by the introduction of plate valves which have been mentioned before in our columns. By far the greatest amount of rebuilding of existing blowing engines has been done by the Mesta Machine Company, of Pittsburgh, Pa., with plate valves manufactured under Iversen patents.

The so-called rebuilding of blowing engines is, in some cases, limited to the simple replacing of the existing valves by automatic plate valves. In other instances it means more than that, namely, the removing of old cylinder heads and replacing them by heads containing plate valves. In the most extreme cases it means the removal of the whole air end, including the air cylinder.

When replacing an old type of valve by plate valves the latter are arranged in cages, which take the place of large poppet valves, originally operating in the head. The cages are dished in order to reduce clearance to a very small amount. In many cases the clearance volume is smaller than it was with the original valves, while in other cases it is increased slightly, depending upon the type of valves being replaced by the cages. But even in this latter case, the advantages gained by the instantaneous opening of the valves, and the larger area secured, are so

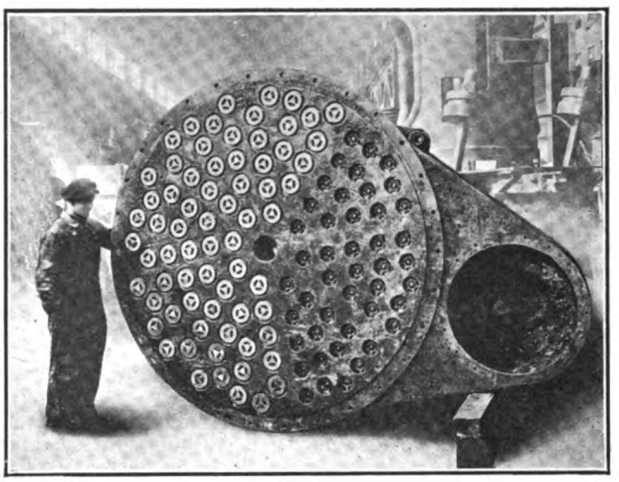

Fig. 2.—Method of replacing existing valves with Iversen plate valves.

overwhelming, that the slight increase in clearance volume fades into insignificance.

The arrangement of the valves in cages offers several advantages. The removal of one cover plate exposes all outlet valves of the cage to inspection on the delivery side. The inlet cages are made in two parts so that the removal of one cover and the top of a cage exposes all the valves of that cage to inspection. In the extremely rare case of breakage of a valve, the whole cage can be easily removed and replaced by a spare one.

Figure 1 shows how valves have been made to fit a segmental arrangement of old valves. Figure 2 illustrates the method of installing valves in place of existing valves in the head. This latter method as a rule gives some increase in valve area, but not enough to warrant increasing the speed of the engine materially. This method is to be recommended particularly in the case of old blowing engines equipped with leather valves. The advantage is two-fold: First, the plate valves are always tight and in consequence deliver more air, whereas leather valves soon begin to

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leak, due to warping or charring of the leather; second, higher pressure can be blown.

The second method, namely, that of replacing old air heads with new ones, is very widely practiced at the present time. Figure 3 shows the appearance of such air heads. The third and last method, namely, that of replacing the old air end has been necessary

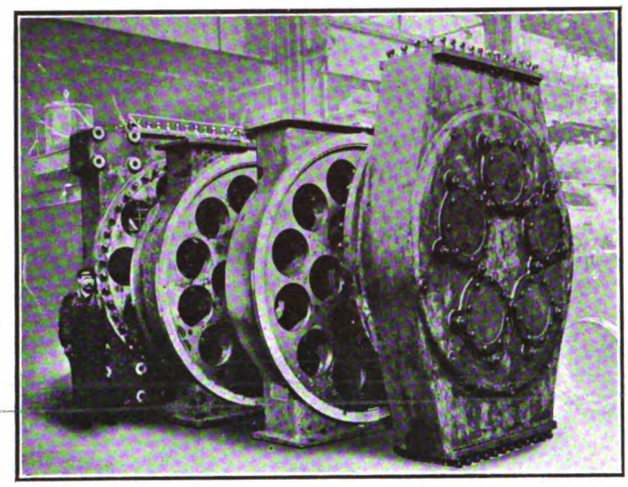

Fig. 3.—Replacing old air heads with new ones.

only very occasionally. Figure 4 shows the appearance of such an air end.

Mention has already been made of the fact that plate valves allow higher piston speeds. This feature is beneficial in several ways. Right now, due to the poor grade of coke available, many furnaces are troubled by the necessity of more air than was used in the past when better coke was on hand. Increasing the supply of air has pulled several furnaces out of a bad predicament. More air means not only more pig iron, but in addition, more furnace gas, more steam and steady profitable operation.

The installation of plate valves, and the resulting possible increase in speed of the blowing engines, has enabled a number of plants to erect another furnace without installing additional blowing units. The

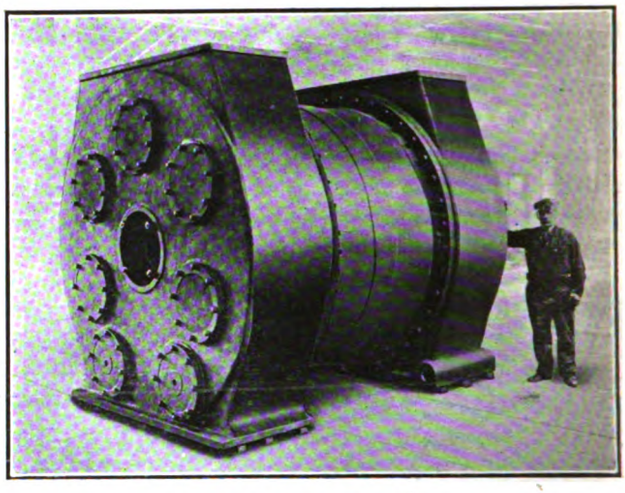

Fig. 4.—Replacing air end.

heretofore customary practice of blowing a furnace with three or sometimes four tubs, has given way to the present possibility of blowing a furnace with two tubs only; and, in fact, a great many furnaces in this country are being blown to-day, using only two 84 in. diameter blowing tubs equipped with automatic plate valves. From this it can be seen that the blowing capacity of existing plants can be increased 50 to 100 per cent by equipping the present engines with automatic plate valves.

Steel Production by the Duplex Process

The Second of a Series of Articles Concerning Duplexing Which Describes the Construction and Operation of the Converters and Open Hearths.

By J. K. FURST,
Vice President and Engineer of the Pennsylvania Engineering Works.

The converters, which are of 25 tons capacity, are spaced 42-ft. to 44-ft. centers, and are located in the duplexing building between the mixers and open hearth furnaces; on the opposite side of the building, adjacent to the outside row of building columns, but sufficiently within the building so that they come within the range of the overhead traveling crane operating over the pouring side of the mixers and the charging side of the open hearth furnaces. By an examination of this arrangement (illustrated in the first article of this series, September, 1917), it will be seen that the metal from the mixers to the converters and the metal from the converters to the open hearth furnaces may be handled with dispatch without interference between the different cranes. Also that the vessels, by their location adjacent to the outside row of building columns, can be blown without interference with the handling of the metal.

While it is important to arrange the plant so that the metal may be handled between the different units with as great dispatch as possible, it is not well to crowd the plant and thereby hamper the operations. Sufficient space should be provided between the converters and open hearth furnaces to facilitate easy operation, provide room for slagging of ladles, clean-up tracks, etc.

The converters as shown in figure 1, are of 25 tons capacity, and are swung on cast iron housings designed with a view of giving the maximum amount of rigidity. The steel casting trunnions were formerly riveted to an annular supporting ring made up of plates and bars. Later, however, it was found advantageous to make the

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supporting ring of cast steel in four segments, the different segments being held together by bolts and heavy shrink links. This supporting ring makes it possible to remove the vessel at any time by means of the overhead traveling crane and the auxiliary trunnions riveted to the nose of the vessel, for either repairing or relining. In fact, at some plants a separate vessel, lined and ready for service, is kept standing convenient to the vessel in operation at all times so that, instead of lining the vessel in place, it is removed and the spare vessel is swung in its place within a few minutes so that the operation of the plant may go on without apparent interruption; after which, the vessel just taken out of service can be skulled and relined at leisure to await the time when it will again take its turn in service.

Attention is here called to the large diameter of the nose of the vessel, which has a tendency to check the velocity of the outblowing gas, thus preventing mechanical loss. It is an improvement over the early Bessemer practice in this country and the present practice as carried on in Europe, where the noses are drawn out to a small diameter.

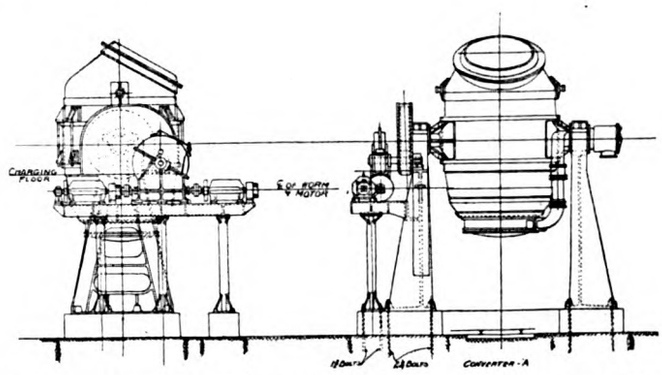

Fig. 1.—Converters of 25 tons capacity, swung on cast iron housings, designed for maximum rigidity.

The cylindrical shell is contracted at its lower extremity in order to lessen the space between the outer row of tuyeres and the side walls, thus bringing the metal more directly over the tuyeres. While this has a tendency to deepen the bath for a given charge of metal, it brings the bath more directly over the tuyere openings and prevents cold metal about the outer circumference. The tuyere plate has 26 tuyere openings, each opening providing space for a refractory 34-in. x 36-in. tuyere. Each tuyere contains 10 tuyere openings varying, according to the judgment of the operator, from ½-in. to ¾-in. diameter, ⅝-in. being the popular size.

The converters are operated electrically, each vessel being provided with two 100 hosepower motors, equipped with brakes and controlled by full magnetic, full re-

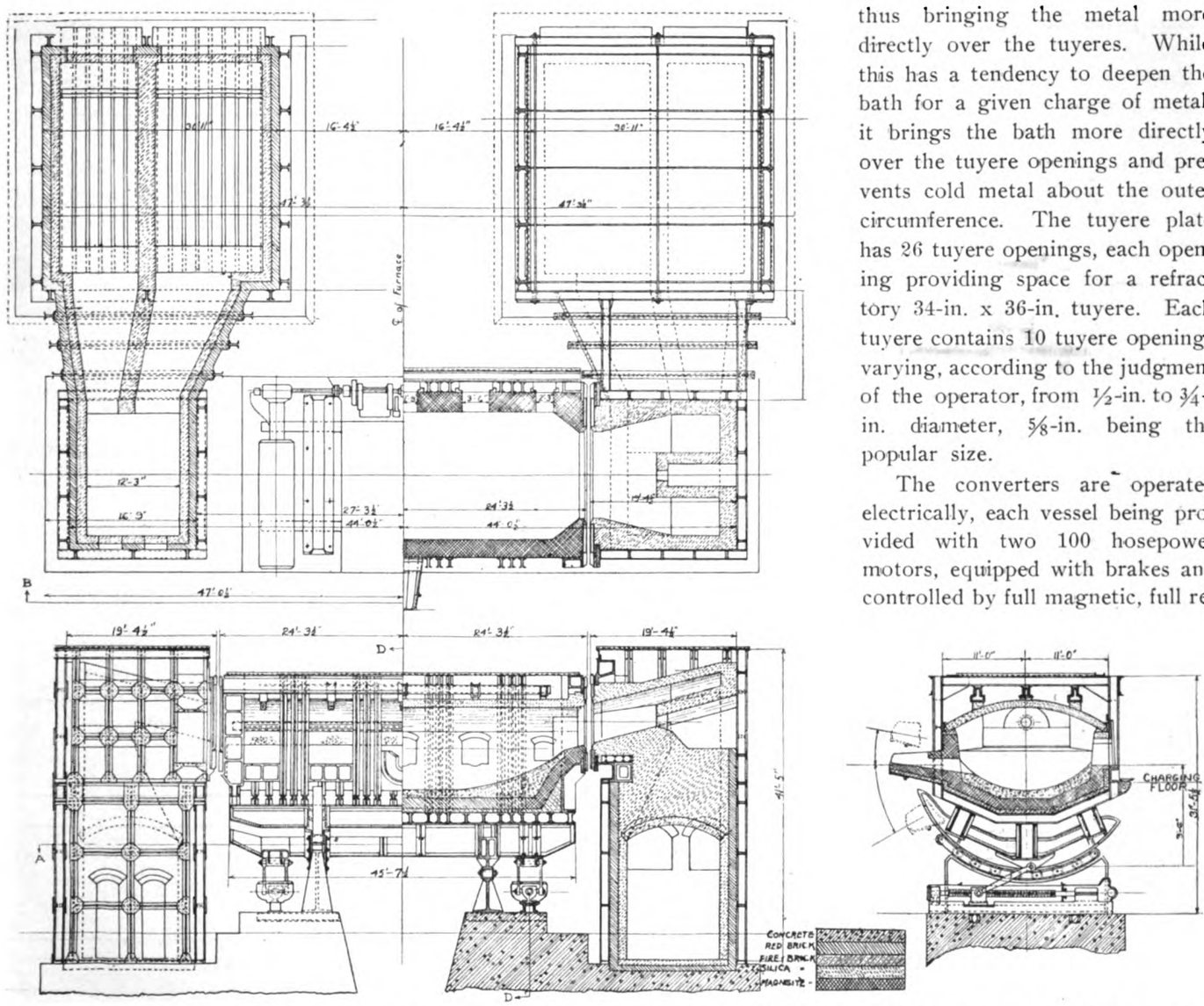

Fig. 2.—200-ton tilting open hearth furnace, mounted on two sets of rollers and stands—The arrangement provides true roller bearing entailing a minimum amount of required power and facile manipulation.

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versing control equipment, arranged to operate the two motors in parallel, similar to that described for the hot metal mixers. If desired, either motor may be operated independently of the other. The motors are back geared, and operate through a worm gear and pinion to the main driving gear keyed direct to the trunnion of the converter.

The blast is supplied at a maximum pressure of 30 pounds and at the rate of 1500 pounds per ton of metal blown, by either reciprocating engines or steam turbo blowers. The blast is conducted to the converters through a 42-in. diameter blast main to the 24-in. blast regulating valves located usually directly under the operator's pulpit. One blast valve is provided for each converter. From here the blast is distributed to the individual converters through 18-in. diameter blast pipes.

An air receiver is usually provided just to the rear of the pulpit, at the extremity of the 42" blast main.

After the metal has been blown, the blow consuming from 12 to 15 minutes, the metal is poured into a 30-ton ladle (illustrated in the first article of this series, September, 1917), and is then picked up by the overhead traveling crane, carried to, and charged directly into, the open hearth furnace. At some of the plants a variation to the above method is employed in the handling of the metal between the converter and the open hearth furnace. By this method the metal is poured into either a bottom-pour or a side-pour ladle from which it is in turn poured into a secondary ladle of sufficient capacity

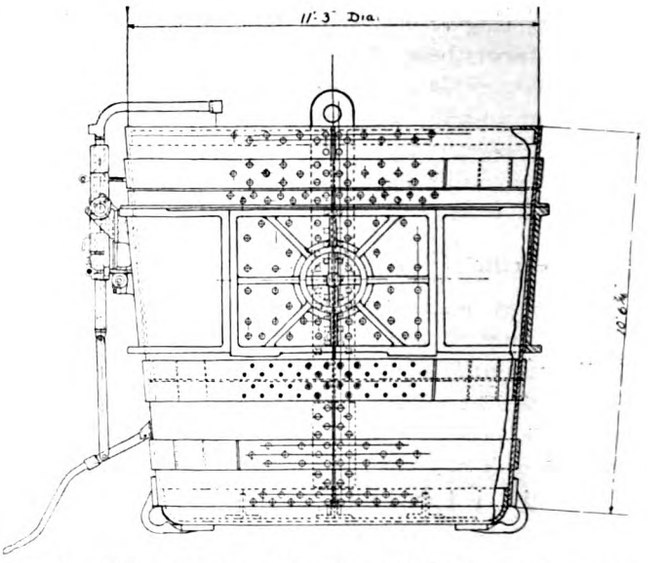

Fig. 3.—100-ton steel ladle, into which the hot metal is poured from the open hearth furnace.

to hold two heats. After the secondary ladle has received the two heats, its contents are charged into the open hearth furnace, either by the lip-pour or side-pour method. By this method, the slag is retained in the primary ladle from which it is dumped from time to time into a slag car or pan standing conveniently by.

In the converter all of the metal is desiliconized and partly decarbonized. In cases where four ladles of blown metal are required for each open hearth heat, ordinarily the first two are blown soft, analyzing:—Carbon 0.1 per cent, Phosphorus 0.7 per cent to 1.0 per cent, Manganese 0.08 per cent; and the second two ladles are partly decarbonized, the percentage of carbon blown out depending upon the amount of scrap charged in the open hearth furnace. Before the blown metal is poured into the open hearth furnaces, burnt lime, iron oxide (the latter in the form of scale or ore) and about 15 per cent of scrap are charged; then the two ladles blown soft are poured in, and lastly the two ladles partly decarbonized, containing 2 per cent carbon, or slightly more, are added. When the second two

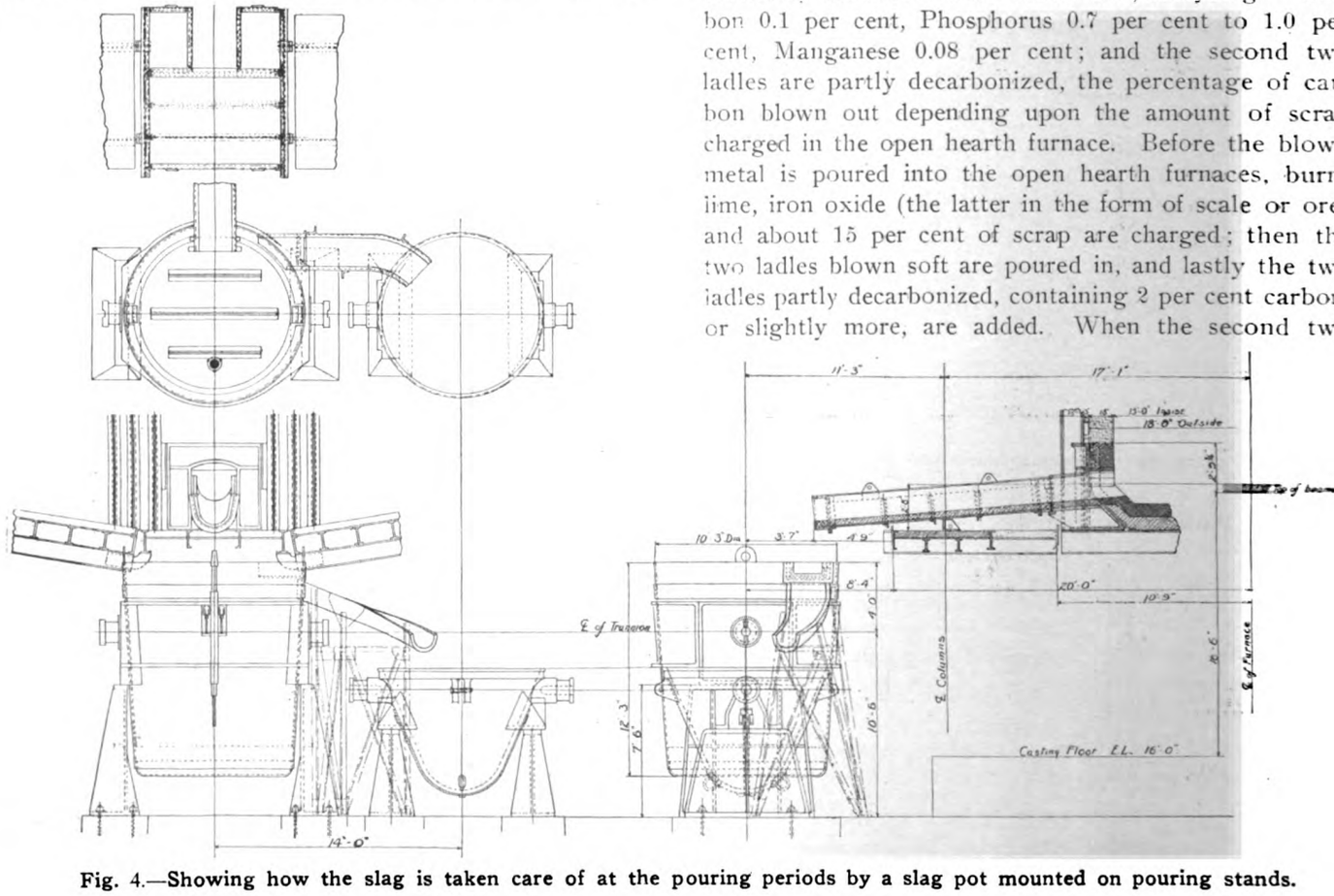

Fig. 4.—Showing how the slag is taken care of at the pouring periods by a slag pot mounted on pouring stands.

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ladles are poured into the open hearth furnace, a violent reaction takes place, which transfers practically all of the phosphorus into the slag. It is here that the advantage of the tilting type of open hearth furnace over the stationary asserts itself, as at this juncture, the furnace is tilted back, allowing the excess of slag to run out of the door into the slag cars beneath the furnace.

Open Hearth.

The open hearth furnace has a nominal capacity of 200 tons, and is of the usual rolling type, except that its supports and overturning mechanism are duplicates of those described for the 1300-ton mixer, with the exception that the open hearth furnace is mounted on two sets of rollers and stands, whereas the mixer has four sets. This arrangement provides true roller bearings entailing a minimum amount of required power and facile manipulation of the furnace. The furnace is shown in Fig. 2. It is equipped with Knox patent water cooled door, frames and chills, and in the present case, has the necessary provision for coal tar fuel. After the heat has been completed in the furnace, it is poured into a 100-ton steel ladle, such as is shown in Fig. 3. The slag at the pouring periods is taken care of by a slag pot mounted on pouring stands, as shown in Fig. 4.

By-Product Coke Oven Pressure Regulation

Theory and Operation of a By-Product Coke Oven Pressure Regulator With a Discussion by the Manufacturer of the Regulator in Question.

By W. TRINKS.

For a maximum output of by-products, the gas must be removed from the coke oven immediately upon its formation. If it tarries in the ovens, decomposition starts, and the output of by-products drops. Uniformity of removal of gas is striven for by the maintaining of a constant pressure (usually a very slight vacuum) at the outlet from the oven.

So important is this consideration that the engineers of by-product coke ovens try to keep the pressure at the oven constant within one or two millimeters of water pressure. If we remember that the pressure of the atmosphere is about 10,000 m.m. of water, then we realize how close this pressure regulation is. It means keeping the pressure constant within 1/100 to 1/50 of 1 per cent. This regulation is so close that it is distributed over two governing systems. The governors on the gas exhausters keep the pressure constant within 10 to 20 m.m. of water, whereas the finer regulation is entrusted to another governor which is known as a "battery governor" or "coke oven pressure regulator."

The purpose of the present article is to give the theory of a widely-used pressure regulator, to point out its limitations, and to stimulate further progress in the problem of close pressure regulation.

Figure 1 is a diagrammatic illustration of the governor in question. A counterweighted, thin walled float dips in oil. Atmospheric pressure acts downward, coke-oven-main pressure and counterweight act upward. If one of the forces exceeds the other, the float moves and closes an electric circuit which, in turn, starts an electric motor and thereby operates a valve in the gas main, varying the rate of flow from the oven to the exhauster. In practice, more machinery is used than is shown in the diagram. Two sets of spur gears are interposed between motor and worm, and a variable lever arm connection is used between the worm gear and the butterfly valve. The whole apparatus is enclosed in a housing which is intended to be air-tight, with the exception of a few small holes at the bottom. This is very important. Wind regularly causes pressures up to 100 m.m. of water, so that wind pressure getting into the governor box would play havoc with regulation which aims to regulate within 2 m.m. pressure. As a matter of fact,

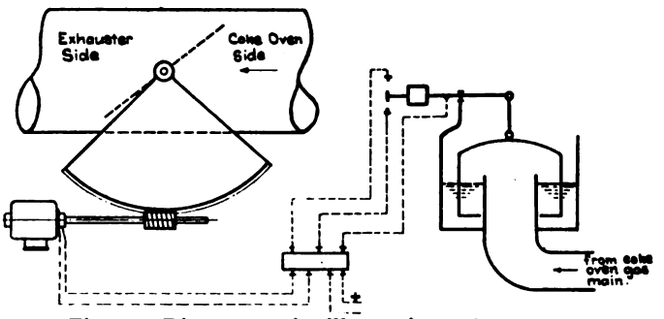

Fig. 1.—Diagrammatic illustration of governor.

regulation is much worse on windy days than it is on calm days. Owing to the delicacy of measurements required, it is still an open question whether regulation is poor on windy days on account of the wind acting upon the leaky structure of the coke oven or whether it is poor on account of the action of the wind pressure on the float in the governor chamber. It may be due to both.

Turning to the theory of the governor, we observe that a very small difference of pressure either way from normal will set the motor going. The time interval required for the float lever to flop from one contact to the other is but a fraction of a second. The governor regulates principally by adusting the area

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A through which the gas flows. Indirectly it affects other quantities as will appear from the following.

In Figure 2, let c_1 be the velocity of approach near the regulating valve, then the velocity in regulating valve is

$$C = \sqrt{C_1^2 + 2g\,(P_1 - P_2)\,V}$$

where v is the specific volume of the gas in the valve. The weight of gas passing the valve in unit time is

$$Q = \frac{KA}{V}\sqrt{C_1^2 + 2g\,(P_1 - P_2)\,V} \qquad (1)$$

where K is a coefficient of contraction. In discussing this equation we note that the valve area A is the principal variable determining Q, as long as the flow of gas remains constant. For variable flow C_1 is of great importance and the equation may be written

$$Q = \frac{KA}{V}\sqrt{\frac{2g\,(P_1 - P_2)\,V}{I - \frac{K^2A^2}{A_1^2}}} \qquad (2)$$

where A_1 is the area of approach.

The first and most important property of a regulating mechanism is stability of regulation. If under conditions of equilibrium, (in this case constant flow, constant pressure), the governor is displaced, it must, to be a good governor, come to rest after a few vibrations.

Let us apply this test to the governor in question. Imagine that the area A is suddenly reduced (for instance by varying the relative position between worm wheel and valve) say to position 1, Figure 3. Then the pressure will rise immediately; there will be a static rise, because more volume comes in from the ovens than passes out at the valve, and a dynamic rise due to inertia of flow. We neglect the second, because it produces a wave motion of much shorter period than one cycle of regulation. After a very short time interval (1)-(2), the governor begins to move as indicated by the line (2)-(3). In order to find out how the pressure on the coke oven side varies, we must write the pressure-volume equation of the coke oven side of the gas main. On account of the reduced area the pressure must rise until the density has risen to such a value that as much flows out as comes in. In the mean time, there occurs a change of weight dQ in the container V_1 which is given the equation

$$dQ = \frac{V_1\,dp}{pv} = \frac{V^1}{v}\,dt - \frac{KA}{V}\sqrt{\quad}\,dt$$

where V^1 is the volume coming in in unit time and $\sqrt{\quad}$ expresses the radical of equation (1). During the interval of one cycle V may be considered as constant. Likewise may C_1 and $(p_1 - p_2)$ be considered constant, because their variation is very small compared to that of the valve area A. Besides, the influence of this disregard will be considered later on. By integration we obtain pressure difference

$$Dp = \frac{Pv^1}{V_1}\,t - P\,\frac{K}{V_1}\sqrt{\quad} \times (\text{integral of } A)$$

But the area varies as a function of time so that $A = A_0 + at$, where A_0 is the initial area, and where a is the rate of change of area. By substitution for A we obtain

$$Dp = \left(P\frac{v^1}{V_1} - P\frac{K}{V_1}\sqrt{\quad}\,A_0\right)t - \frac{1}{2}P\frac{K}{V_1}\sqrt{\quad}\,at^2 \qquad (3)$$

This is the equation of a parabola, the apex of which occurs, if $KA\sqrt{\quad} = V^1$, that is to say, if A has reached the normal value from which it was suddenly changed, see point (3). But at that time the pressure has risen an amount which can be computed from equation 3, and the governor motor keeps on going so as to bring the pressure down to normal. But when the latter desirable condition is brought about—point (5)—the governor valve is at (6) and is farther away from normal position than it was at the beginning of the disturbance—point (1). The time lag (1)-(2) is to be blamed for the increase of amplitude. A new time lag (6)-(7) makes matters still worse for the next vibration and so on. A small vibration, once started, will keep on getting worse until the influence of variation of $(p_1 - p_2)$ counteracts the influence of the time lag. It should be noted that, as A increases beyond certain limits, $(p_1 - p_2)$ decreases rapidly, so that its rapid falling off will counteract the growth of A in equation (1). From that point on, the amplitude of vibration remains constant, unless it is broken up by change in rate of gas flow, or by vibrations of the exhauster governors.

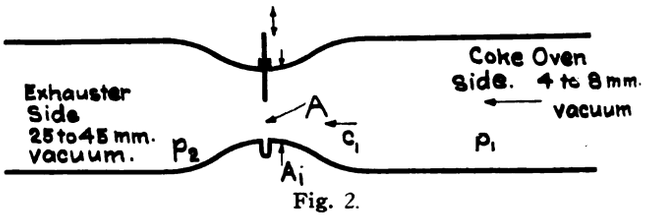

Fig. 2.

From Figure 3 one may take that greater speed of the governor valve will move point (3) to the left and will result in a smaller pressure rise of the first wave. However, the time lag, no matter how small, will gradually increase the amplitude and will finally bring it up to the before-mentioned value where K, $(p_1 - p_2)$ etc. are no longer constant, but reduce the effect of variation of A. Besides, a very quick operation of the regulating valve upsets the exhauster governors in case of a sudden variation in gas supply.

In practice these vibrations are easily observed. The governor is never still, except accidentally, when a wave of change in gas quantity or wind pressure happens to counteract a vibration.

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The governor in question regulates after a fashion, without any doubt, but it is essentially a hunting governor. It is built on the principle of the original relay governors for hydraulic turbines which by means of a clutch pulled the gate up or down. The theory of these old hydraulic governors is almost identical with the one here given, except that speed enters instead of pressure. Hydraulic governors have been improved by the addition of compensating and damping devices. It will be interesting to observe whether or not such additions will be made to coke oven pressure governors.

Relay governors of the type under discussion can be improved by time switches. While the author does not know of an automatic time switch having been applied to a coke oven pressure regulator, he knows of current interruption having been applied by hand, in case of excessive vibrations of the whole governing system. Referring to Figure 3, imagine the current suddenly interrupted at points (8) and (9),

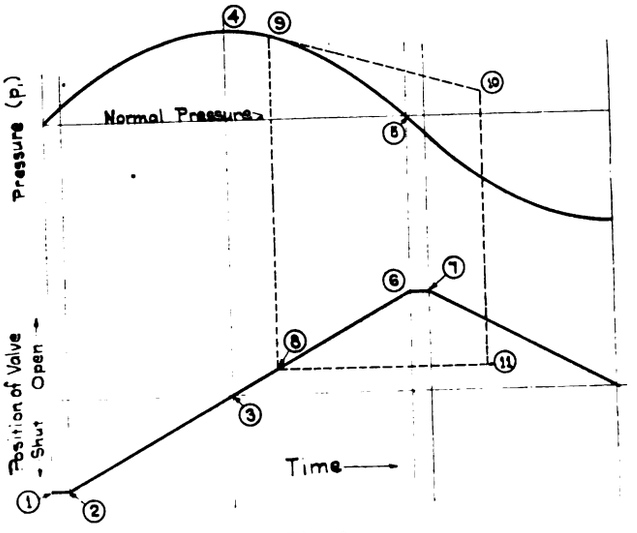

Fig. 3.

and re-established at points (10) and (11). Then the governor remains motionless from (8) to (11), while the pressure drops in a straight line from (9) to (10). But points (10) and (11) are closer to the correct average position than the starting points were so that the interruption was beneficial. Of course, this method is very crude, because it is most beneficial only, if the current is interrupted while the governor travels away from correct position. For best results the interrupter should be automatic and should act on the outstroke only.

Discussion of Prof. Trinks' Article on Pressure Regulators of By-Product Coke Ovens.

Prof. Trinks' emphasis on the necessity for the rapid removal of the gas from the ovens is well placed. If it were possible, gas oven engineers would put the ovens under considerable vacuum, but if this were done, air would leak in, which would be very detrimental to the by-products, as well as dangerous at very nearly atmospheric pressure. Most operating engineers try to keep within the limits of + 2 m.m., — O.m.m.

In the regulator described by Prof. Trinks, these limits of pressure are maintained, as is shown from the chart, (Figure 1) taken from a hydrometer connected to a block of ovens, controlled by one of these regulators. This does not represent an exceptional chart, but what can be obtained under good operating conditions.

Prof Trinks' theoretical examination of the problem of a coke oven regulator is interesting. The suggestion of interrupting the circuit of the motor for a predetermined length of time, so that the pressure and volume can have time to follow the movement of the valve is also good. This method is used on the Royce governor. This is known as the "run and rest" method of regulation.

The operation of a regulator built on this principle, is to produce a gradual change in conditions by a series of short movements of the valve followed by periods of rest after each movement. This will produce an average rate of change depending upon.

1.—The period of run.
2.—The period of rest.
3.—The rate of movement of the valve.
4.—The volume of gas reservoir capacity.
5.—Rate of change of gas volume coming off the ovens.
6.—Rate of change of exhaust suction.

The ratio of the periods of "run" to the periods of "rest," together with the speed of the valve will determine the average speed of the valve.

This average speed of the valve may be either continuous, or made up of intermittent movements of the valve. If these periods are relatively short the general effect will be the same.

Referring to Figure 3 of Prof. Trinks' article, he shows a curve of pressure and assumes that the valve can be displaced a considerable amount instantly after which the pressure change will take place, also that the pressure change is relatively slow.

In omitting to take into consideration the change in value of $P_1 - P_2$ during one cycle of variation, at the same time assuming a change in value of A — which must also change the pressure it would seem that this assumption could not be made.

Also, if the pressure curve (9) would fall to (10), as he says, if the valve were stopped at (8)—or in a tangent to the curve at this point, it would seem by the same reasoning that if the valve were stopped at (3), that the pressure would

(Continued on Page 482.)

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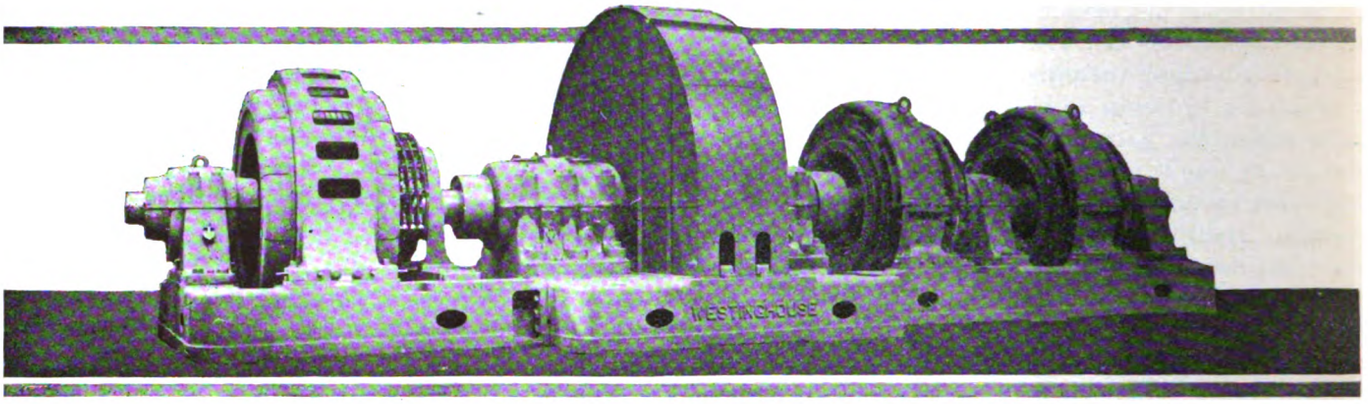

Electric Drives for Reversing Mills

Reversing Mill Drives Considered from the Standpoint of Cost of Equipment, Efficiency, and Reliability—Description of Operation of This Type of Drive.

By D. M. PETTY,

Superintendent Electrical Department, Bethlehem Steel Company.

The question of electric drives for reversing rolling mills one and two years ago was largely a matter of comparison with the steam engine drive, while to-day it has reached the point where electric drive is admitted to be superior except where local conditions are very favorable to the steam engine.

It will be the object of this paper to point out some of the points that may be improved in the electric drive rather than to compare it with the steam engine drive, trusting that some points will serve as suggestions to other operating engineers.

Reversing mill drives are practically all of the Ilgner type which consists primarily of an adjustable voltage motor generator set with a fly wheel, an adjustable voltage mill motor and an exciter set along with the necessary control apparatus. The ordinary arrangement and connections are shown in Figure 1. Briefly, the operation is as follows:

The main motor "M" takes power from the incoming lines and drives a motor generator set, a flywheel being mounted on the same line of shafting. This motor, if a-c., is of the slip ring type and has an automatic slip regulator in its secondary circuit. This regulator is operated by a torque motor which takes power from current transformers in the primary leads of the driving motor, and as the load increases, the torque of the regulating motor increases, and the plates of the regulator are separated, this inserting resistance in the main motor secondary, causing its speed to fall off. This causes the flywheel to deliver some of its stored energy to the generators.

The armature of the d-c. generator "G" of the motor generator set is connected electrically to the armature of the d-c. motor "M M" which in turn is connected mechanically to the mill. In some cases there may be more than one generator and more than one mill motor such as shown in Figure 1.

The motor has its field excited in the same direction at all times and reversal is obtained by changing the direction of flow of current through its armature. This is accomplished by reversing the polarity of the generators. The speed of the motor from zero up to some predetermined point is determined by the voltage impressed across its armature, and above that point its field is weakened, the impressed voltage remaining constant.

If we assume the mill motor running full speed, i. e., with full voltage and with weakened field, and it is desired to reverse, the sequence of operation is: First, strengthen the motor field which will make it act as a generator and return power to the generator set, and then, weaken the generator fields which will continue this action still further and finally reverse the generator field which will reverse the flow of current through the armature circuit and cause the direction of rotation to change.

The generator fields are excited from a constant potential exciter and the motor field is also excited from this same exciter. Sometimes there is in addition to this a variable potential exciter which furnishes excitation to the motor in proportion to the load, in other words is equivalent to a series winding on the main fields of the mill motor. This point will be discussed more fully later.

Since it is the function of the electric drive to furnish power for rolling cost, it will not be out of place to dis-

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cuss some of the factors that enter into cost of rolling steel in the mill and endeavor to point out how these may be kept down to a minimum.

In general there are three items that enter into the cost of rolling steel which are affected by the drive.

First—Cost of equipment.

Second—Efficiency.

Third—Reliability.

All other considerations will come under one or the other of these headings and they are all closely connected one to the other.

Cost of Equipment.

One of the best means to reduce the cost of the equipment per ton of steel rolled is to increase production. It is unnecessary to produce figures to show that money spent to increase production is money well invested, for it is almost an axiom among steel mill operators. But we should not add mechanisms of any kind that do not in some way or another decrease the cost per ton of steel rolled.

Efficiency.

It may be that a certain refinement will make the drive more efficient; if so, and it does not hinder operation any other way, it is well to adopt it, for it not only will reduce the kw-hrs. per ton but it will also reduce the size, and hence the cost, of the drive to do a given work or allow it to do more work, but it will also reduce the capacity required in the power station. This will either reduce the cost of the station or release station capacity for other work.

Reliability.

Delays are the most serious hindrances and keep the rolling costs up as much as any other factor in mill operation, therefore it is necessary that all the machinery entering into a mill drive should be thoroughly reliable It must be designed so that trouble can be easily found and quickly repaired, this means it must be as simple as possible.

Let us study the drive by following the flow of energy from the power mains to the mill as shown in Figure 1, and discuss each link as to its reliability, efficiency and cost.

Passing from the disconnecting switches to the oil switch and primary windings of the motor, there is little in this link that needs comment, except as to reliability. It is a very grave mistake to install any apparatus whatsoever in this link except that which is fully up to the standards of the rest of the equipment. The oil switch should be of sufficient capacity to handle a short circuit without throwing oil over other parts of the equipment.

The primary windings of the driving motor, which is assumed to be a high voltage induction motor, should not only be liberally rated in order to keep up its efficiency, but its insulation should be such as to stand high temperatures as well as moistures. The former condition is very apt to obtain in the summer months and the latter if the mill is shut down for any length of time, allowing condensation to take place.

The bearings and shaft should be very liberally rated and designed for ring oiling, but gravity oil feed should be provided so as to insure against the possibility of letting the rotor down on the stator iron. This it is readily seen would be more serious than is the case with an ordinary induction motor because the inertia of the flywheel will keep the set spinning for two or three hours.

It is common practice in this country to locate the flywheel between the driving motor and the generators, letting the flywheel bearings serve as one bearing for

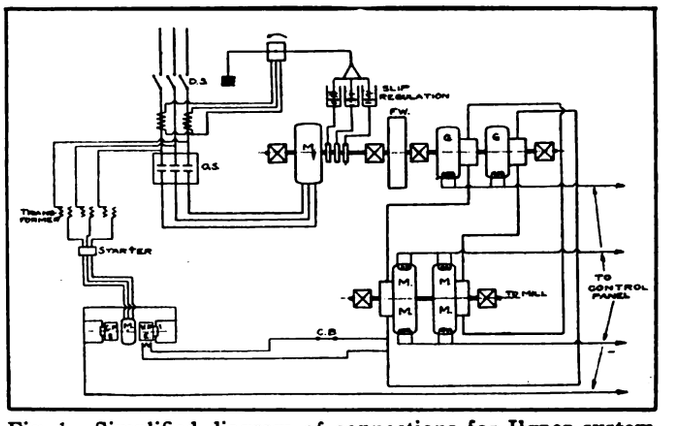

Fig. 1.—Simplified diagram of connections for Ilgner system. Reversing motor and motor generator set such as is illustrated above headline of this article.

the motor and one for the generator. If the flywheel is located on the opposite end of the generators from the motor and is carried in a separate pair of bearings with a flexible coupling, wear of the flywheel bearings will not affect the operation of either the generators or the motor. This would be an especially good arrangement if two motors and two sets of generators were used in connection with one flywheel.

The design of the shaft should be ample not only for twisting strength but for stiffness.

The flywheel should be designed with a high factor of safety, machined to insure good balance and the rim should be protected with a shield to reduce air friction.

The d-c. generators are usually built for 600 volts or more and are not only equipped with interpoles, but also with compensating windings in the main pole faces.

The commutators should be very liberally designed and have extra wearing depth of bars. Extra length of crepage distance should be provided on each end of the commutators to prevent flash-over to ground. The commutators of the generators are one of the weakest points in the entire system and too much care cannot be taken to make them right.

The brushes should be of the highest quality and contain no abrasive material as the mica should be kept undercut. The current density in the brushes should be kept low and shunts should have ample current carrying capacity.

That which is true of the generator commutators is

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also true of the mill motors. In this case the motor commutator is much larger in diameter but shorter, with a larger number of brushes.

The motors must be ventilated by a forced draft which should be washed unless the air is taken from outside the mill and is free from the usual dust and gases of a rolling mill. The air must be properly distributed through the motors so as to avoid hot spots in the windings.

When two or more generators are used they should be connected in series as shown in Figure 1, as this connection keeps the voltage to ground equal to that of one generator.

There is some question as to whether the motors should be compound or shunt wound. A compound winding on the motor gives it somewhat of a cushion against severe overloads and to a certain extent protects not only the motor but also the machinery of the mill. It also tends to increase the torque of the mill motor for a given armature current but this is not very much at full field, i. e., slow speeds, where maximum torque is needed, because the shunt field windings are then at their maximum excitation and the additional excitation produced by the series windings does not produce a proportionate amount of field flux. When the field has been weakened to give high speeds the compounding will be much more effective but then the motor should not slow down for it is desired to run at high speeds. A compound wound motor can have a lower horsepower rating to handle a given peak load but it does this at the expense of production. A shunt wound motor to handle the same peak loads would have to be larger than the compound wound motor and it will tend to increase production. Under these conditions the generators for the shunt motor will have to be larger than for the compound wound motor which will tend to further increase the cost of the equipment over that of the compound motor.

The compounding of the mill motor is usually accomplished by having a variable potential exciter for the field current and therefore the voltage of which varies as the load current of the mill motor. This arrangement is necessary because the series of the motor must be in the same direction for both directions of rotation and since the load current reverses each time the motor reverses, the connections of variable potential exciter to the motor fields must be reversed with each reversal of the mill. This can and is easily taken care of in the master controller. Omitting the compound field, however, tends to simplify the master controller and this is a desirable feature as simplicity insures continuity of operation. It would seem therefore that a shunt wound motor should be used unless the mill is to be a slow one or one subject to severe peak loads at frequent intervals.

The time of reversal of the motor has been brought up in comparing it with the steam engine and it is admitted that the engine can reverse quicker, but this is not the most important point to be considered in selecting the drive for a mill. Steel must be entered in the rolls at low speed and the motor must be capable of accelerating quickly with the piece in the rolls.

The bearings of the motor must be provided with constant oil feed because rings will not carry oil when running on a shaft which changes its direction of rotation often. The bearing pedestal next to the mill must be designed to stand the thrust of a broken spindle and provided with a thrust bearing. These bearings are also provided with cooling coils, but if possible the mill is laid out for continuous operation.

The exciter set is a small item in the first cost but a necessary link in the chain, and must therefore be liberally rated. A spare should be provided if the mill is laid out for continuous operation.

The control contactors should be designed for hard service and installed so as to facilitate repairs. The controller by which the engineer operates the mill should be made as fool proof and simple as possible, and too much care cannot be used in the makeup and design of this piece of apparatus. Terminal boards plainly marked should be used at both ends of all control circuits. This is especially good practice when the wires are grouped together in one conduit.

Finally it can be said that to keep the rolling costs down we must first of all eliminate delays. This is best accomplished by designing all parts of the equipment with a large factor of safety, making it simple to operate, as well as easy to repair.

Statistics.

The following is the data of the drive in the No. 2 mill of Bethlehem Steel Company, South Bethlehem:

35-in. blooming mill.

Speed full motor field,—40 r.p.m.

Speed weakened motor field—120 r.p.m.

Voltage across each armature—600.

Maximum operating torque—1,550,000 ft. lbs.

Maximum motor horsepower—12,000.

Rated capacity of motor generator set—2,000 kw.

Weight of flywheel—100,000 pounds.

Synchronous speed of motor generator set—375 rpm

Average for one month—21.3 kw-hrs. per ton.

(Rolling equal quantities of 4-in. x 4-in. and 9-in. x 9-in. blooms from 23-in. x 27-in. ingots, 40 to 50 carbon.)

Best record, 12 hours—19.41 kw. hrs. per ton.

(Rolling 8-in. x 8-in. from 23-in. x 27-in. ingot, 32 to 36 carbon.)

The average tonnage is 17,180 tons per month. The fact that much more than this could be rolled if other mill conditions did not prevent, shows that less than 19 kw-hrs. per ton would be reached if the mill should run at maximum capacity.

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Operation of Heroult Electric Furnaces

Operating Characteristics—Voltage Relations for Various Currents—Vector Diagrams for Power Factor and Losses. Consideration of Skin Effect of the Conductors.

By WALTER C. KENNEDY,

Chief Engineer, Standard Seamless Tube Company.

The use of the electric furnace in the steel industry has increased to such an extent that its permanency is now assured. At first, it was used for high carbon and alloy steels, but it is now extending to the manufacture of lower carbon steels comparable with the grades at present produced in the open hearth furnace. The electric furnace, like the electric motor, has advanced directly with the comparatively recent and rapid growth of the modern power distribution systems. As nearly all power systems are supplying sixty-cycle, three-phase current, it is entirely pertinent to consider the growth of the use and size of the electric furnace along this line.

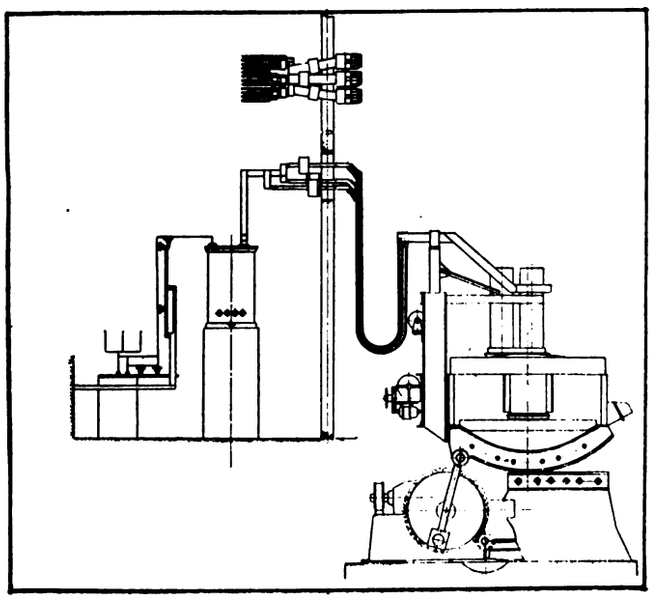

Fig. 1.—Arrangement of furnace leads, transformer and oil switches.

The majority of electric arc furnaces for the manufacture of steel or other ferrous alloys run from five or six tons' capacity down. Next in size is the 10-ton furnace and the largest sizes in practical use in this country are of 15-20 tons' capacity per charge.

It is the intention of this paper to show a few electrical characteristics of a 15-ton Heroult furnace operating on 60-cycle, three-phase current. The results obtained indicate very good performance. In fact, we can reasonably look forward to furnaces of increased sizes to follow, using this same frequency.

Paper read before the eleventh annual convention of the A. I. S. E. E., Philadelphia, September, 1917.

Figure 1 shows the arrangement of furnace leads transformer and oil switches.

The following table gives the data of the various parts of the equipment:

Capacity of furnace—15 tons.
Number of electrodes—3.
Size of each electrode—24 in. diameter.
Transformer—one, three phase.
Primary voltage—22,000.
Secondary voltage—173-100.
Amperes per phase—12,500.
K.v.a. rating—3,750.
Reactance—10 per cent approximately.
Electrode cables—12,-2,000,000 c.m. per phase.
Lead resistance—.000016 ohms.

The transformer is three-phase, water-cooled. It is arranged with star delta connection of the primary to give 173 or 100 volts on the secondary. The secondary coils are permanently connected in delta, the arrangement of connections being shown in Figure 11. The automatic electrode regulating apparatus was fully described in Mr. Richardson's paper in last year's A. I. S. E. E. proceedings, and details of operations will not be further discussed.

There is one point, however, brought up in Mr. Richardson's paper that it would be well to confirm at this time. As mentioned by him, the instrument panel contains the following measuring instruments:

1—Voltmeter.
1—Curve drawing wattmeter.
1—Power factor meter.
3—Indicating wattmeters.
1—Watthour meter.

The wattmeters, one on each phase, should be changed to ammeters as some difficulty has been been experienced in their operation. As shown later, the power factor of the furnace circuit, even on this large size and 60 cycles, is practically 100 per cent, so that ammeters would give a sufficiently close power indication. At any rate, the total power is shown by the curve drawing polyphase wattmeter. The ammeter is more reliable, and moreover, the automatic regulator regulates according to current and this therefore is the indication that should be shown on the indicating meters. Again, trouble may be experienced if wattmeters are used. The contact-making ammeters operating the electrode motor circuits operate against spring tension. Now, it is possible to adjust this spring tension and therefore to unbalance the current in that particular phase. If, then, the adjustments are made to show equal watts on the three

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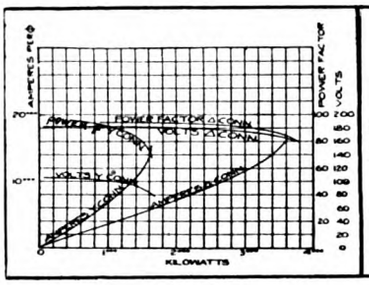

Fig. 2.

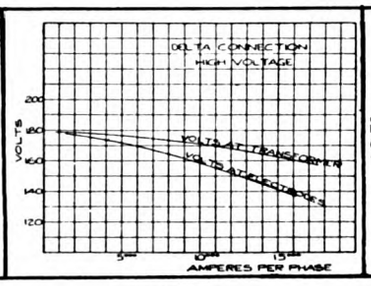

Fig. 3.

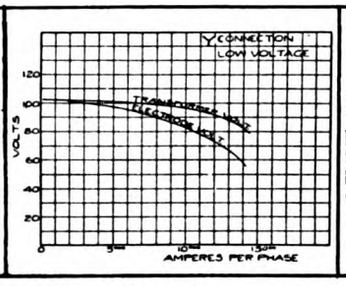

Fig. 4.

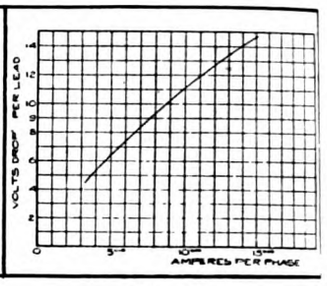

Fig. 5.

Fig. 2.—General operating characteristics—Figs. 3, 4 and 5.—Represent voltage relation for various currents.

phases, the voltages will be unequal, which will cause the arcs to vary in length. Trouble was experienced from this cause in which one arc (or the unbalanced phase) burned the side wall of the furnace. Since that time, steps were taken to change to ammeters.

Figure 2 shows the operating characteristics, both on the star and delta connections referred to kilowatts input. In normal operation, the high voltage is used to melt down the cold charge, which requires about three hours (input 2,500 to 3,000 kw.). After the charge is melted, the low voltage at about 1,000 kw. is used to refine the steel. Also, the temperature proper for pouring is regulated by varying the input a short time before tapping. The furnace was charged with cold open hearth scrap and pig, low in phosphorus. One slag only was used, the final analysis of the steel being approximately:

C.	.15 per cent
Mn.	.37 per cent
Ph.	.02 per cent
Sul.	.03 per cent
Total kilowatt hours	7,500
Kilowatt hours, per ton	500

The above is a representative heat although local conditions will considerably affect the operation and power consumption.

It is interesting to compare the results of operation, Figures 2 to 7. Figure 2 shows the general operating characteristics. It is evident that on low voltage (Y connection) in order to get a power factor about 90 per cent, that the maximum input is limited to 1,000 to 1,200 kw. It is better to keep within this range as the current is then kept down to 7,000 to 8,500 amperes and the conductor losses therefore correspondingly reduced. (See Figure 7.). On high voltage (delta connection) 3,200 kw. input can be obtained without any difficulty, although in practice 2,400 to 2,800 kw. is the usual load. A study of figures 3 to 10 shows the relation of the current, power factor, skin effect, and losses in the secondary or electrode circuit. Figures 3, 4 and 5 represent voltage relations for various currents. These were used to obtain the power factor and losses by the method shown by the Vector diagrams, Figures 8, 9 and 10.

Referring to Figure 8:

O C = Transformer voltage to neutral point.

O A = voltage from electrode to neutral point.

A C = voltage drop across one lead.

The current in the arc is of unity power factor and therefore is in phase with the voltage. That is, in phase with OA. If there were no skin effect, the distance A-D would represent the actual resistance drop in the cables. If skin effect were present, we can represent conditions as shown in Figure 9. Here A-B represents the resistance drop as calculated by the measured resistance of the cables times the current. B-D represents the increased resistance drop due to skin effect which forces some cables to carry more current than others, thereby increasing the effective resistance. Actually, AB is very small; for example .15 volt for 10,000 amperes (2.6 kw.) so that it is neglected and the drop A-D considered entirely due to skin effect. It is quite noticeable, in operation, that a few of the cables, about 3 or 4 on each phase, are distinctly hotter than others.

The power factor is represented by the cosine of the angle COD. In Figure 6 the volts resistance drop represents the values A-D given in Figure 9. The ohms resistance per cable is obtained by dividing

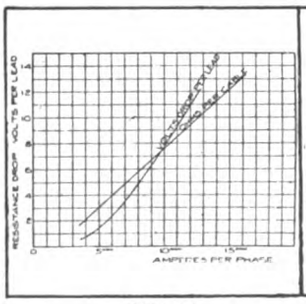

Fig. 6.

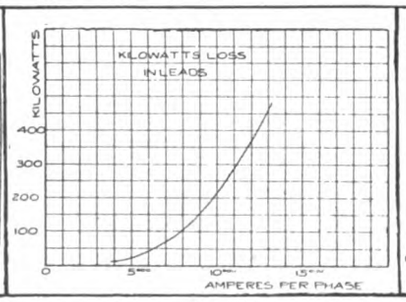

Fig. 7.

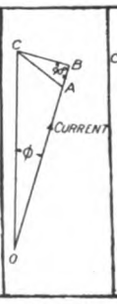

Fig. 8.

Fig. 9.

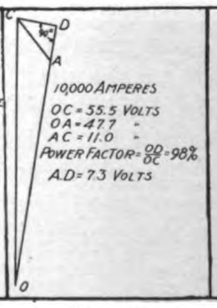

Fig. 10.

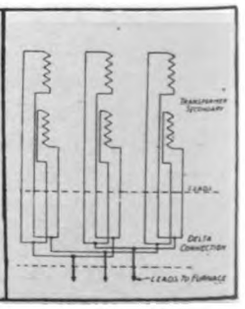

Fig. 11.

Figs. 6-10.—Relation of current, power factor, skin effects and losses in the secondary or electrode circuit—Fig. 11.—Arrangement of connections.

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the volts drop by the corresponding current values. The apparent increase in resistance of the lead is due to the increasing action of the skin effect for heavier currents.

Figure 10 shows a diagram to scale for low voltage and 10,000 amperes. Values are indicated. It will be noted that the power factor is practically unity for all values of current and either low or high voltages—if anything, higher on the high voltage. The watts lost in the three leads are represented by the energy components A-B and are shown in Figure 7. The above results illustrate that the operation of large electric furnaces is entirely practical on 60 cycle circuits, and that the successful operation is dependent upon using two, or possibly more, voltages. At least, it is a big advantage to have more than one voltage available, the high voltage to be used for melting down and low voltage for refining. That the inductance in the secondary leads need not cause any concern but rather the skin effect of the conductors is the greater item.

In this furnace, as in all others at present constructed, the three phase leads are grouped into three cables before leading to the electrode holders on the furnace. The writer believes that this should be changed (at least on 60 cycle furnaces) in order to reduce the skin effect. The phases should be broken up, say into six leads with the phases interlaced. These six, or possibly twelve, leads should run from the transformer to the furnace. The delta connection should then be mounted on the furnace. It would be entirely feasible to do this and still take care of any current transformers in the secondary circuits. For example, in the present case, this would save probably about 30 kilowatt hours per ton of metal. With a large furnace and high voltage so that a heavy input can be obtained, quick melting is possible. This reduces the loss by radiation and helps materially to lower the power consumption per ton of metal.

We can reasonably expect the use of electric furnaces in the future to be applied more and more in the manufacture of the lower carbon steels, as it is possible to obtain a better steel. This is true because the steel is more free from gases and oxides and also the temperature, especially at pouring, can be more accurately controlled.

The process followed in making steel is that common to all electric furnaces. This process comprises two stages: the oxidation stage and the reducing stage, each employing one slag. In the oxidation stage, phosphorus is removed in exactly the same manner as in standard open hearth practice. In the reducing stage, sulphur and oxygen are removed. The neutral atmosphere of the electric furnace (containing no oxygen or sulphur) is here an advantage.

A second slag is made containing calcium and carbon in excess. The sulphur is removed as calcium sulphide. The completion of the reducing action is indicated by the presence of calcium carbide in the slag. The better quality of electric steel is believed to be due to this last, or reducing stage, with the neutral and non-oxidizing atmosphere of the furnace. Also due to the neutral condition, it is easier to obtain uniform heats, an advantage peculiar to the electric furnace. There are undoubtedly less bad heats with electric steel practice than with open hearth practice.

British Iron and Steel Institute Meeting

The autumn meeting of the British Iron and Steel Institute was held at the Institute of Civil Engineers, London, England, on September 20-21 inclusive. At the Thursday morning meeting new members were elected to the Institute. The following is a list of papers that were to be submited for reading and discussion:-

G. Barrett and T. B. Rogerson:—"Present Practice in Briquetting of Iron Ores."

W. J. Brooke and F. F. Hunting:—"Microstructure of Commercially Pure Iron between A_3 and A_2."

E. D. Campbell and W. C. Dowd:—"The Influence of Heat Treatment on the Electrical and Thermal Resistivity and Thermo-electric-potential of some Steels."

G. Chappy and A. Cornu-Thenard:—"New Impact Testing Experiments."

J. E. Hurst:—"Heat Treatment of Grey Cast Iron"

E. F. Law:—"Effect of Mass on Heat Treatment."

T. D. Morgans and F. Rogers:—"Investigation upon a Cast of Acid Open Hearth Steel."

F. Rogers:—"The Acid Open Hearth Process."

J. H. Whiteley:—"The Eggertz Test for combined Carbon in Steel."

E. B. Wolff:—"Failure of Boiler Plates in Service and Investigation of Stresses occuring in Riveted Joints."

"The Eggertz Test for Combined Carbon in Steel" deals with the subject in a most thorough manner. A method is described for the estimation of small amounts of carbon dioxide by absorption in ammoniacal chloride solution, by means of this method the carbon content of the gases evolved in the Eggertz test is ascertained. The work is divided into four parts, each dealing with a separate phase of the test.

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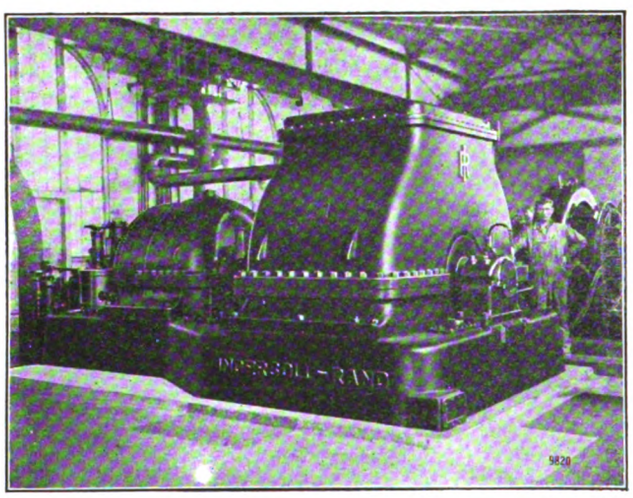
PRODUCTION TOPICS

TURBO BLOWER IN STEEL MILLS.

Among the improvements of the past few years in blast furnace and steel plant practice, one of the most noteworthy has been the adoption of the turbo type of blowing engine. In practically all the new installations the modern high speed turbo blower has superseded the long stroke reciprocating unit.

To-day, the practical success of plant operation is dependent upon the installation of mechanical equipment which combines highest economy with absolute reliability. In blowing engines the ideal is most nearly approached in the turbo unit. Economy is secured by the use of steam turbines designed to operate on high pressure steam, low pressure steam or a combination of the two; and also by the utilization of high pressure superheated steam exhausting into higher vacuum than is possible with reciprocating engines. The air end of the machine is of modern efficient design and is water cooled. As to reliability, the turbos installed give sound evidence that this type can be depended upon for satisfactory 24 hours per day service. The



Ingersoll-Rand turbo-blower.

main reason for this is that there are no parts to get out of order. The rotating element has no rubbing surfaces; and the bearings alone need lubrication. These are automatically and positively oiled by a force feed system driven from the main shaft.

The turbo blower occupies only a portion of the floor space required for reciprocating types and the cost of foundation, installation and building is relatively less.

Blast furnace turbo blowers are regularly equipped with a regulating device which automatically maintains constant volume. Converter blowers are fitted with automatic constant pressure regulators.

Turbo blowers also find application in the field of gas boosting.

Evidence of the popularity of the turbo blower as standard blast equipment is found in a survey of the increasing number of plants which have installed or are planning to install them. Among recently installed units are the following built by the Ingersoll-Rand Company.

	Free air capacity cu. ft. per min each unit.	Pressure lbs. per sq. in. gauge.	Type of drive	Service
Tennessee Coal Iron & R. R. Co., Ensley. Ala.	55,000	20–30	Mixed press. Steam Turbine	Furnace
Detroit Iron & Steel Co., Detroit, Mich.	28,000–33,000	13–15	Live Steam Turbine	Blast Furnace
Pulaski Iron Co., Pulaski, Va.	22,500	13	Live Steam Turbine	Blast Furnace
Mitsubishi Goshi, Kaisha, Korea.	23.000	15	Live Steam Turbine	Furnace
Mark Mfg. Co., Chicago, Ill.	25,000	25–30	Live Steam Turbine	Bessemer Converter
Tata Iron & Steel Co., Ltd., India.	35,000	10-15	Live Steam Turbine	Blast Furnace
Whittaker-Glessner Co. Wheeling, W. Va.	45,000	15–30	Live Steam Turbine	Blast Furnace
Tennessee Coal, Iron & R. R. Co., Ensley, Ala.,	25,000	30	Mixed Press. Steam Turbine	Bessemer Converter
Mark Mfg. Co., Chicago, Ill.,	45,000	18-22	Live Steam Turbine	Blast Furnace
Brier Hill Steel Co., Youngstown, Ohio.	45,000	15–22	Live Steam Turbine	Blast Furnace
Alan Wood Iron & Steel Co. Conshohocken, Pa.,	45,000	15-22	Live Steam Turbine	Blast Furnace
National Tube Co., Wheeling, W. Va.,	25,000	15	Exhaust Steam Turbine	Blast Furnace
National Tube Co., Wheeling, W. Va.,	13,500	25	Exhaust Steam Turbine	Bessemer Converter
Carnegie Steel Co., Pittsburgh, Pa.	54,000	7–15	Live (Steam) Turbine	Coke Oven (Gas Boosting)

The Crab Orchard Iron & Steel Company, Bristol, Va. and Chicago, has acquired the local furnace of the Virginia Iron, Coal & Coke Company, and is said to be planning for the construction of a new open hearth plant with daily capacity of about 150 tons. It is proposed to have the plant in operation by the close of the year.

An electrically-operated movable car dumper has just recently been installed by the Wellman-Seaver-Morgan Company, for the Alan Wood Iron & Steel Company, at Swedeland, Pa. The equipment is modeled on the well-known substantial lines.

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PRODUCTION TOPICS

PERFORMANCE OF UNIFLOW ENGINE IN STEEL MILL.

After sixteen months' service a uniflow engine installed in the steel plant of the L. F. Shoemaker Company, at Pottstown, Pa., was tested by the engineers of the steel company and showed very high economy, especially at small loads. The uniflow type of reciprocating engine is especially designed to maintain a steady temperature gradient in the cylinder and to operate at low constant losses, and, by means of an unusually simple valve gear, over a considerable range of load.

The engine which was tested is an Ames-Stumpf uniflow engine having a 19-inch diameter cylinder with 24-inch stroke The engine is direct-connected with 200-kilowatt, 250-volt, direct-current Crocker-Wheeler generator, which furnishes energy for electric cranes, heavy punches, shears, and general motor loads, and, in addition, all energy for the entire lighting system. The load is extremely variable, there being frequent flash-load fluctuations from one-half load to 25 per cent overload. The unit operates at 200 r. p. m. with a pressure at the throttle vale ranging from 135 pounds to 150 pounds, with practically uniform vacuum, and is rated at 320 indicated horsepower with 150 pounds pressure, cutting off at one-fifth of the stroke.

The test is especially striking because it was made on an engine which had been working for many months in a steel mill. The vacuum was not particularly good, only 26 inches, and the running conditions for efficiency none the best. Considering all the conditions, the results were highly satisfactory for a simple condensing engine working over a wide range of power. Particularly noteworthy is the exceptionally uniform efficiency obtaned through a range varying from quarter load to one and a quarter times full load, the variation in efficiency between these limits being approximately 10 per cent. The average consumption of dry steam per indicated horsepower at full load was down to the very creditable figure of 15 pounds, particularly as this result was a little better than that obtained before a forced run of sixteen months, giving the equivalent of two and a half years' operation on an ordinary ten-hour-a-day basis. The results show plainly that the development of new ideas in engine construction may well lead to real advances, despite the common belief that the reciprocating engine has reached about its ultimate development.—From the Journal of the Franklin Institute.

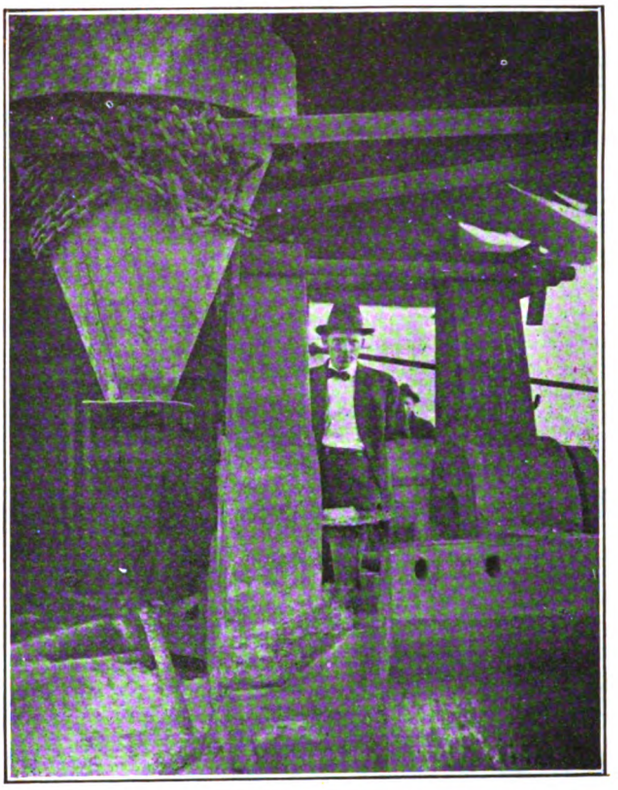
The Taylor Instrument Companies. of Rochester, N. Y., descripe the manufacture, installation and application of their pyrometers in a catalogue recently issued by them.

THERMIT WELDING.

The accompanying illustration shows a thermit weld accomplished by John Weida, manager and superintendent of the Canton Drop Forge Company, Canton, O.

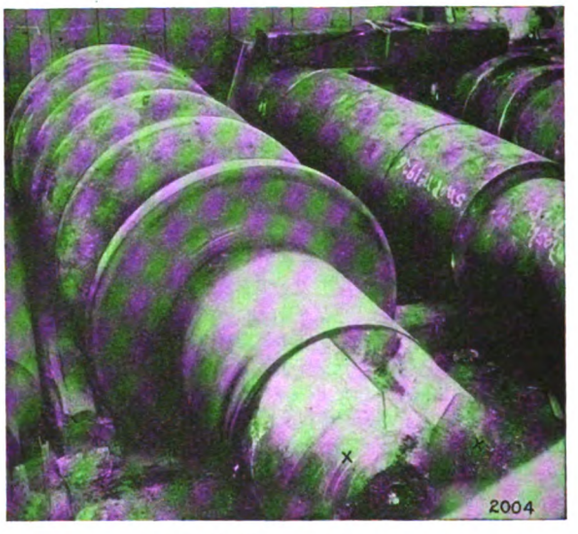
In the majority of cases thermit welding is practised more in railroad shops than in any other industry and although the finished weld is not a thing of beauty it is nevertheless much stronger than when originally made.

This form of a 30-inch alligator shear broke one day while under a heavy strain and since it had to be used a great deal in the shop, its repair was necessary. Mr. Weida decided to try a thermit weld, so the necessary thermit sand, fire clay, crucible, oil burner and mold box were secured and the weld was accomplished with excellent results. The frame was tested after being welded and proved to be stronger than before. Since this frame is cast iron this weld



can be considered a little out of the ordinary, and shows the new possibilities of the thermit weld in similar shops.

The following illustration shows the welding of rolls by the Goldschmidt Thermit Company, of New York. In most



Roll after welding.

cases a roll with the wobblers so badly damaged would be useless, however, as shown the weld has made the roll practically new.

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NEWS OF THE PLANTS

AMERICAN GEAR MANUFACTURERS' MEETING.

The American Gear Manufacturers' Association held its semi-annual session in Chicago, Thursday, Friday and Saturday, September 13, 14 and 15, at the Edgewater Beach Hotel. The Association numbers among its members practically all of the prominent gear manufacturers in the country. The Chicago session was the largest of any yet convened.

Special importance was attached to the present meeting because of the members' desire to effect as much standardization in gear products as possible—this in common with the government's desires for all industry, now that the war is making special demands upon all manufacturers and users of materials.

F. W. Sinram, of Van Dorn, Dutton & Company, Cleveland, president of the organization, opened the session Friday morning at 10 o'clock. A paper on "Advertising Dont's" was then read by J. C. McQuiston, advertising manager of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. W. H. Phillips, of R. D. Nuttall Company, Pittsburgh, followed it with a talk on the "Heat Treating and Hardening of Gears."

Saturday, a paper by B. S. Waterman, Brown & Sharpe Manufacturing Company, on "Inspection of Gearing," was read; also another by H. E. Eberhardt, of the Newark Gear Cutting Machine Company, on "Spur Gearing by the Rotary or Disc Cutting Process," and another by F. Schneider, of Van Dorn, Dutton & Company, Cleveland, on "Spur Gears by the Shaper Method." All papers read at the convention were instructive and promoted much discussion.

WOMEN IN STEEL WORKS.

With the calling of the first increment of the draft army only a few days in the distance, the labor shortage which is already felt in the steel industry, will become a greater and more serious problem. Women are already being employed in some plants, although to no considerable extent, but it is quite probable that more employment of this nature will soon be in evidence. England, of course, has been facing this problem for some time and it is interesting to note the varieties of work which women have successfully performed. They are attending power plants, taking charge of switchboards, operating cranes, erecting machinery, unloading railroad cars, handling coal, weighing, etc. The National Gas Council, of England, has published a list, classifying the industrial work in which women can be employed successfully.

FEDERAL EXPORT CORPORATION ELECTION.

The announcement made recently by the Federal Export Corporation of the election of Samuel Armstrong Benner as vice president and manager of the iron and steel department indicates the increasing demands for raw and finished steels that are being made on this country by foreign buyers. When the Federal Export Corporation first turned its attention to the requirements of the European countries for steel and iron, the principal buyers wer the government departments. To-day the demand comes in a growing volume from the private industries which have succeeded in reorganizing their plants so they are enabled to carry a sufficient output to cover their own government's orders and provide for the local business which was stopped at the commencement of the war. Mr. Benner brings to his new connection an experience of many years in selling American iron and steel to the overseas markets. Before coming to the Federal Export Corporation, Mr. Benner was general manager of sales for the American Stel Export Company. His previous connections were with the Carnegie Steel Company as foreign and general sales manager and with the Pittsburgh Steel Company as assistant to the president.

DUST FUEL FOR BOILERS DISCUSSED.

The Society of Chemical Industry, London, recently discussed the advantages of dust fuel for boilers in connection with a paper by C. A. King, on tests made with a Bettington boiler of the Farnley Iron Company. The small coal, he said, was pulverized, passed through a sieve of 200 meshes per linear inch, and sent up vertically into the combustion chamber, formed by semi-circular firebricks lining the innermost ring of tubes. The ashes were converted into a semi-liquid spray which trickled down from the lining, thus heating the gases once more in their fall, which they would not do with a horizontal furnace arrangement. Some of the large particles of the coal escaped unburnt. During the discussion B. G. McLellan mentioned that he had tested a Bettington boiler some years ago; owing to the expense incurred in preparing the dust fuel he had found the dust fuel only profitable with low-grade coal; but then the flame tended to go out; soft water was, moreover, imperative, lest the intensely hot flame burn the tubes, and the insulation was a weak point in the Bettington boiler; he also expected trouble from the action of the ash on the firebricks, unless the ash and lining were either both acid or both basic. Mr. King partly admitted the force of these objections, but thought that even a fairly good coal would show an increased efficiency when pulverised; coke breeze should be very finely pulverized; there had been no trouble with the flame going out.

TO ROLL STEEL WHEELS.

The Detroit Pressed Steel Company, of Detroit, Mich. have awarded a contract to the Heinle Company, metal-rolling enginers of Pittsburgh, for the development of a machine to roll steel whels for automobiles.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace & Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant,** published monthly, at Pittsburgh, Pa. [Report for October 1, 1917.]

Publisher—National Iron and Steel Publishing Company, 108 Smithfield street, Pittsburgh, Pa.

Editor—A. M. Staehle, 108 Smithfield street, Pittsburgh, Pa.

Managing Editor—Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Business Manager—Adam W. Tritsch, 108 Smithfield street, Pittsburgh, Pa.

(Names and addresses of stockholders holding 1 per cent or more of total amount of stock):

Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.
E. E. Phelps, Controller's Office, Pittsburgh, Pa.
R. E. Densmore, 612 Union Trust Building, Detroit, Mich.
Mary A. Howe Estate, Pittsburgh, Pa.
Adam W. Tritsch, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

ADAM W. TRITSCH, Business Manager.

Sworn to and subscribed before me this 18th day of September, 1917.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1919.)

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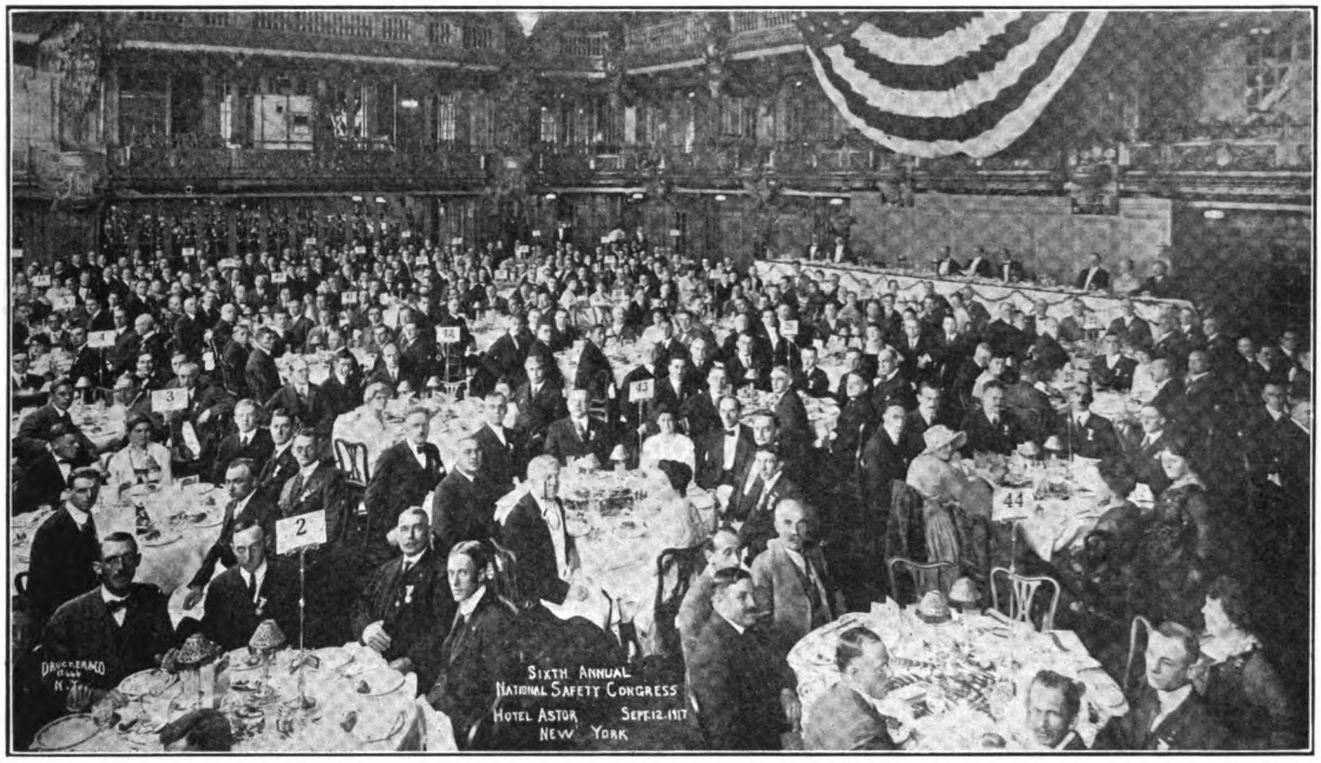
INDUSTRIAL SAFETY

SIXTH ANNUAL SAFETY CONGRESS.

The sixth annual safety congress was held at the hotel Astor, New York, September 11, 12, 13 and 14, during which meeting the necessity for the safety of human life at the present time of labor shortage was particularly emphasized. It is interesting to note that the safety council held a meeting at the same time as the Association of Iron and Steel Electrical Engineers, inasmuch as the later societyformed the National Safety Council at a meeting held in Milwaukee in 1913. Since this time growth of the safety council has been nothing short of phenomenal having at the present time a membership of over 3000. The congress was divided into several sections, each section holding seperate meetings. The iron and steel section attracted the largest number of interested members, from 300 to 1,000 being in attendance. The iron and steel section commenced on Wednesday and awsin charge of George T. Fonda, and Earl B. Morgan. Mr.



L. H. Burnett, assistant to the president, Carnegie Steel Comdistrict safety inspector, of the American Steel and Wire pany, Pittsburgh, read a paper entitled "Unsettled Accident Prevention Problems in Iron and Steel Industries." The "Analysis of Accidents" was discussed by Dr. Lucian W. Chancy, of the U. S. Dept. of Labor, Washington, D. C. Dr. D. R. Kennedy, assistant to the president of the Youngstown Sheet and Tube Company and L. W. Hatch, chief statistician, of the Department of Labor State of New York, entered into the discussion of these papers.

On Thursday F. G. Bennet, safty director of the Buckeye Steel Castings Company, opened the session with a paper on "Safety in Yard Practises" J. Stanford Brown, supervisor, Department of labor, Safety and Welfare. of the Carpenter Steel Company, presented a journal discussion of this paper. Frank E. Morris Safety Engineer of the American Rolling Mil Company, Middletown, Ohio read an extremely interesting paper entitled "Safe Practices in Sheet Mills" which was discussed by J. M. Woltz, safety director, Youngstown Sheet and Tube Company. Leslie M. Rice, Company, Worcester, Mass., emphasized the necessity of drilling th furnace crew for emergencies in bottom blow outs, in his paper on "Safe Practices in Sheet Mills." A bridge lined with asbestos on the under side, to be used to reach the furnace in the event of failure of the arch, was described by F. B. Morgan, of the Norton Company, Worcester. George T. Fonda emphasized the necessity of inspecting ingot molds in describing a serious accident. C. R. Lobbs, Midvale Steel Company, and J. C. Smith, Inland Steel Company, entered into further discussion concerning dangers of ingot pouring.

The greater liability of accidents to untrained and inexperienced men was pointed out by Dudley R. Kennedy, assistant to the president, of the Youngstown Sheet & Tube Company, in the Friday morning session. Negro labor was discussed. "Low Voltage Hazards" were described by Dr. C. A. Lauffer in a paper by that title, in which he emphasized the necessity f oreducation as means of promoting the principles of safety first. The discussions brought out methods of reviving the victim from the effects of electric shock. A round table discussion was held following this power in which the question of eye protection received considerable attention. Few cases of eye injuries are said to be caused due to goggles breaking.

The following new officers were elcted: President, D. Van Schaack, Hartford, Conn.; S. S. W. Tener, Cleveland; J. M. Eaton, Detroit; W. L. Chandler, Mishawaka, Ind.; general manager, W. H. Cameron; assistant secretary, J. J. Lamont; field secretary, C. W. Price; editor, E. R. Rice.

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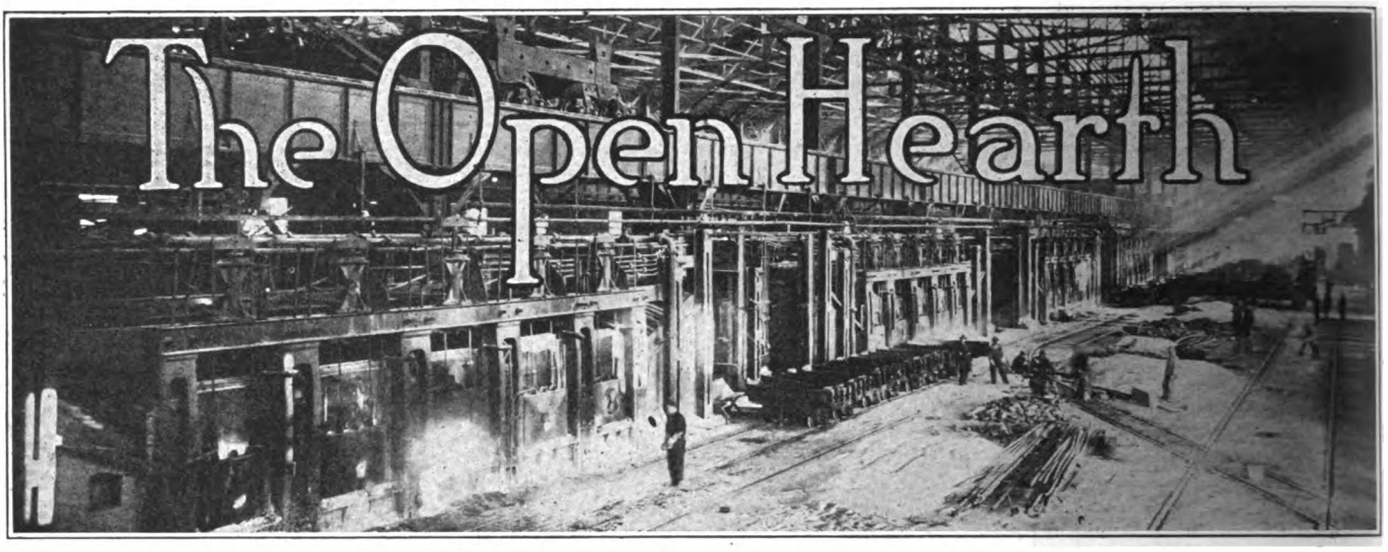

Max McMurray, general manager of blast furnaces of the M. A. Hanna & Company, since 1904, has been elected president of the newly-organized Cromwell Steel Company, Cleveland, Ohio. Mr. McMurray was formerly assistant superintendent of the Joliet works of the Illinois Steel Company, general superintendent of the Newburgh works of the American Steel & Wire Company, and general manager of the United Iron & Steel Company, the Detroit Iron & Steel Company, and the Penn Iron & Coal Company.

V V

George J. Sturmfelzs, Jr., has resigned from the position of boiler house engineer with the E. I. du Pont de Nemours & Company, and is now superintendent of boilers with the Bethlehem Steel Company, Sparrows Point, Md.

V V

W. O. Renkin, formerly chief engineer with the A. M. Byers Company, is now chief engineer of the Quigley Furnace Specialties Company.

V V

W. E. Firth, for a number of years safety engineer with the Midvale Steel Company, Nicetown, Philadelphia, has resigned to take an extended vacation.

V V

Norman Q. McClure, for the past three years chief engineer of the Phoenix Iron Company, Phoenixville, Pa., has resigned that position and formed a connection with the Taylor-Wharton Iron & Steel Company, of High Bridge, N. J. Mr. McClure will assist for the time being in the construction and operation of the extension to the plant of the Tioga Steel & Iron Company, Philadelphia.

V V

James Lloyd is now general superintendent of the operating department of the Sharon Steel Hoop Company. He was formerly assistant superintendent of the Southside plant of the Jones & Laughlin Steel Company, Pittsburgh.

V V

Edward O. Acker, for 29 years metallurgist for the Bethlehem Steel Company, has retired from active work.

V V

Roy A. Lewis has recently been appointed general superintendent of the Bethlehem plants of the Bethlehem Steel Company. Mr. Lewis has had a vast experience as a mechanical engineer, having been connected with Kilby Manufacturing Company, Cleveland; Bay City Sugar Company, Bay City, Mich.; Wellman-Seaver-Morgan Company, Cleveland; Mesta Machine Company, Pittsburgh, and United Steel Company, Canton. Immediately previous to his appointment he was general superintendent of the Lehigh plant of the Bethlehem Steel Company.

Timothy Burns has been transferred from the Maryland plant of the American Steel & Wire Company, to act as superintendent of the Saucon plant of the Bethlehem Steel Company, to succeed L. W. Adams, resigned.

V V

James Nelson has returned to the Algoma Steel Company, having been in charge of the duplex department of the Bethlehem Steel Company, at Bethlehem, Pa., for some time. Mr. Nelson held the position of open hearth superintendent at the Ohio works of the Carnegie Steel Company, Youngstown, Ohio, for a number of years.

V V

L. V. Hess, from the Joliet plant of the Illinois Steel Company, has recently been appointed chief electrician of the Youngstown Sheet & Tube Company, Youngstown, Ohio.

V V

F. O. Kichline has been transferred to the open hearth department of the American Iron & Steel plant from the Saucon laboratory, of the Bethlehem Steel Company, where he was chief chemist.

V V

Lewis M. Ream, formerly assistant superintendent at the south works of the American Steel & Wire Company, has been accepted as an instructor in the aviation corps.

V V

A. L. Phelps has accepted a position with the National Carbon Company, Niagara Falls, N. Y. He was formerly superintendent of the Youngstown, Ohio, plant of the United Engineering & Foundry Company.

V V

Paul Caldwell, of the Pittsburgh office of the General Electric Company, has accepted a position with the Cleveland Crane & Engineering Company, in the sales department, and will take charge of its New York office about October 1.

V V

J. Y. Blackwood is now chief engineer of the Corrigan, McKinney & Company, steel plant and blast furnaces. He succeeds Mr. H. T. Harrison, who has been appointed general manager of the firm.

V V

Lawrence H. Cooney, general manager of the Algoma Steel Company, and for many years in charge of the rolling mills department of the Ohio works, Carnegie Steel Company, Youngstown, Ohio, has resigned.

V V

Alfred G. Place, formerly chief electrician of the Youngstown Sheet & Tube Company, Youngstown, Ohio, is now a consulting electrical engineer.

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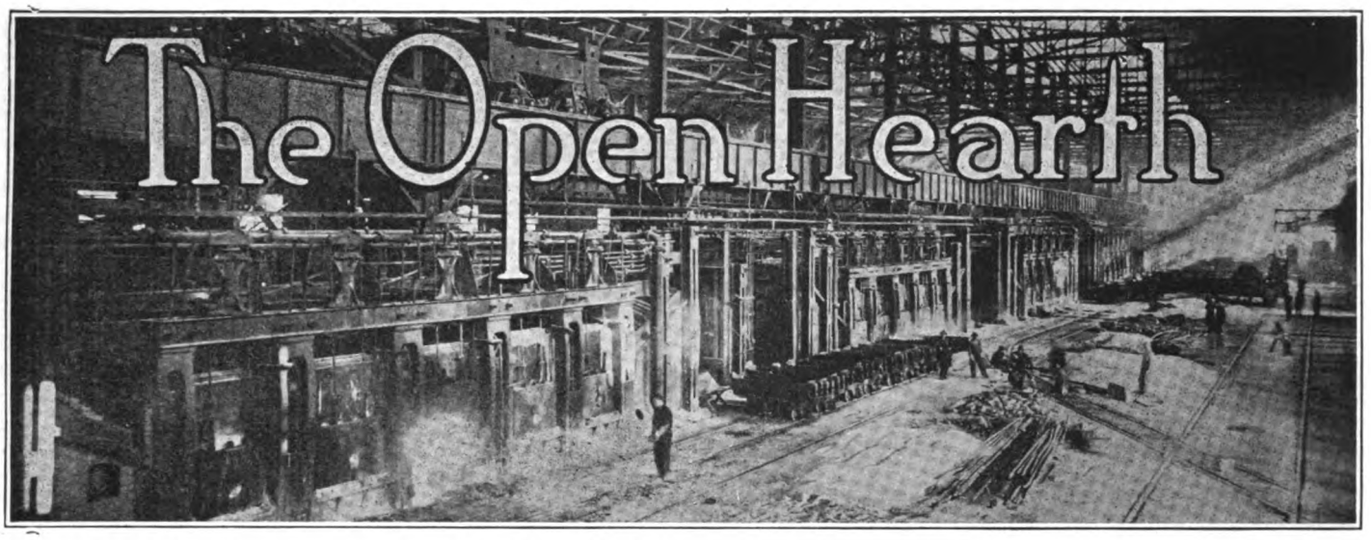

A. N. Diehl, assistant general superintendent of the Duquesne plant, Duquesne works of the Carnegie Steel Company, has been appointed assistant to the vice president.

V V

P. J. Moran has been apointed general manager of the blast furnaces of the M. A. Hanna & Company, succeeding Max McMurray.

V V

George A. Paff is now superintendent of the Page Woven Wire Fence Company, Monessen, Pa. He was superintendent of the rod and wire mills of the Jones & Laughlin Steel Company, Aliquippa works, for eight years. Previous to this he was superintendent of the rod and wire mills of the American Steel & Wire Company, Sharon plant.

V V

Henry D. Booth, formerly in charge of the munition department of hte Midvale Steel Company, has been appointed superintendent to succeed George Satterthwaite.

V V

William B. Curtis, of the Youngstown Sheet & Tube Company, Youngstown, O., has been appointed as a lieutenant in the ordnance department of the officers reserve corps.

V V

W. A. Janssen has been appointed operating manager of the plants of the Canadian Steel Foundries, Ltd., Montreal. He recently resigned as superintendent of the Bettendorf Company plant, Bettendorf, Ia.

V V

Perley R. Prescott, formerly consulting engineer with the Erie City Iron Works, will be connected with the American Trading Company, in Japan, where he will install engineering plants.

V V

Edward T. Moore has recently accepted a position with the Halcomb Steel Company, and the Syracuse Crucible Steel Company, Syracuse, N. Y., as electrical engineer. He was formerly with the Westinghouse Electric & Manufacturing Company.

V V

George O. Klaiss, formerly with the Bethlehem Steel Company, at Steelton, is now assistant superintendent of the forge shops at the Easton plant, William Wharton, Jr., Company.

V V

F. W. Brooke, formerly metallurgist for the Ludlum Steel Company, Watervliet, N. Y., is now in charge of the construction of the Greaves-Etchells furnaces, with the Electric Furnace Construction Company, Philadelphia.

The following are elected to membership of the American Iron and Steel Institute, September 26, 1917, subject to occurrence of vacancy: S. T. McCall, secretary-treasurer, American Manganese Steel Company, Chicago, Ill.; H. H. Newson, director of purchases, the Standard Parts Company, Cleveland, O.; Robert W. Waltenbach, vice president, McMyler-Interstate Company, Bedford, O.; Joseph B. Andrews, president, the Andrews Steel Company, Newport, Ky.; Paul Sturtevant, banker, director of American Rolling Mill Company, Pittsburgh, Pa.; Louis J. Lind, vice president, Witherow Steel Company, Pittsburgh, Pa.; Dan J. Ryan, president and general manager, Allyne-Ryan Foundry Company, Cleveland, O.; Michael J. Sweeney, vice president and treasurer, Allyne-Ryan Foundry Company, Cleveland, O.; James Harvey Williams, president, J. H. Williams & Company, Brooklyn, N. Y.; William F. Witherow, president, Witherow Steel Company, Pittsburgh, Pa.; Joseph a Krantz, secretary, Reeves Manufacturing Company, Canal Dover, O.; John Goodin Carrothers, assistant manager of sales, Carnegie Steel Company, Cincinnati, O.; Francis S. MacIlvaine, metallurgical engineer, Lukens Steel Company, Coatesville, Pa.; Louis Follet, president, Standard Tin Plate Company, Canonsburg, Pa.; Arthur J. Krentz, treasurer, the Reeves Manufacturing Company, Canal Dover, O.; Sterling F. Delano, sales manager, the Linde Air Products Company, New York City; Peter Richard Foley, general manager of sales, the Eastern Steel Company, Philadelphia, Pa.; Joseph Warner, president and general manager, Warner Iron Company, Nashville, Tenn.; Ernest Hallock Webb, president, the Webb Wire Works, New Brunswick, N. J.; William Dalton, general manager, Washington Steel & Ordnance Company, Washington, D. C.; Henry C. DuBois, Philadelphia, Pa., manufacturer of ferro-manganese; Oden H. Wharton, president, Crucible Steel Company of America, Pittsburgh, Pa.; Banks Hudson, general manager, Princess Furnace Company, Inc., Glen Wilton, Va.

V V

John E. Woods, formerly manager of sales of the Carnegie Steel Company, Illinois Steel Company and the Tennessee Coal, Iron and Railroad Company, at Cincinnati, Ohio, has been oppointed assistant general manager in succession to Mr. Dix, deceased.

V V

A. D. Shankland is now chief chemist at the Saucon laboratory of the Bethlehem Steel Company.

V V

R. B. Woodworth has been appointed advertising manager and sales statistician .

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Some Pointers on By-Product Coke Oven Operations

BY-PRODUCT COKE OVEN PRESSURE REGULATION

(Continued from Page 461.)

continue tangent to the point (4),—which is manifestly impossible.

In actual conditions, where the valve is close to the ovens, it can only be moved a small amount without an immediate change in pressure. Also, the rate of change of the valve is relatively slower than that shown.

If these are plotted, we get a curve in which the pressure rises rapidly to a maximum and slowly returns to normal. A curve of this character shows very little tendency to "hunt." In actual practice there is no trouble of this kind, except when caused by periodic fluctuations of the exhauster regulators.

In the regulator under discussion, the contact is only made after a change in pressure of about ½ m.m. + or — from the amount for which it is adjusted. If, therefore, the pressure increases more than ½ m.m. the contact is made and the valve starts moving in such direction as to bring the pressure back to normal. As soon as it comes to within ½ m.m. of normal the contact is broken and the valve remains in the new position. The pressure may fall until it is ½ m.m. below the normal in which case the contact is made and the valve is moved in the opposite direction.

The speed of the valve is so selected that it does not "over-run," but follows up at about the same rate as the average change of pressure, due to increased volume, when a newly-charged oven is put on.

There is practically no time lag due to inertia of parts as these are made of aluminum, as far as possible, and mounted on hardened steel knife edges.

The regulator is designed to maintain the pressure within the limits of 2m.m. of water with the usual changes in gas volumes due to connecting one or two ovens at a time and cutting off ovens when ready to push. It is assumed that the exhauster regulator will maintain the suction on the other side of the valve approximately constant.

Prof. Trinks refers to old hydraulic governors as an example of a similar problem, but conditions were altogether different. The inertia of the water, water wheel, and gates were all very great, also they had to govern for all kinds of variations in load. In the gas oven regulator there is practically no inertia of the gas or governor parts. Also there is a self centering feature of the gas regulator which tends to bring it to rest in the normal position.

Prof. Trinks admits that the governors in question "regulate after a fashion" and after looking at the charts taken from numerous ovens controlled by these regulators most engineers will agree with him.

FREDERICK W. ELLS.

In further reference to the discussion on coke oven governors the statements of the original contribution need no modification, but the following additions will be of interst in view of the evidence offered by the builders of the governor under discussion.

Under the assumed conditions, the variation of $(p_1 - p_2)$ can indeed be neglected compared to the variation of A. I have satisfied myself that the governor in question is utterly unstable with quick variations of volume of gas or with quick variations of pressure coming from the exhauster governor. There exist, however, other conditions, under which the variation of $(p_1 - p_2)$ cannot be neglected, and under which the governor becomes stable. Imagine the changes in quantity of gas and in pressure to be exceedingly slow, and imagine the governor to be so set that it moves the regulating valve very slowly. Then in that case the pressures have a long time for their equalization, and a small change of A may bring about quite a change of $(p_1 - p_2)$. But an increase of A, in this case of very slow changes, ultimately means quite a reduction of $(p_1 - p_2)$ which partly counteracts the increase of A. The regulation has become stable.

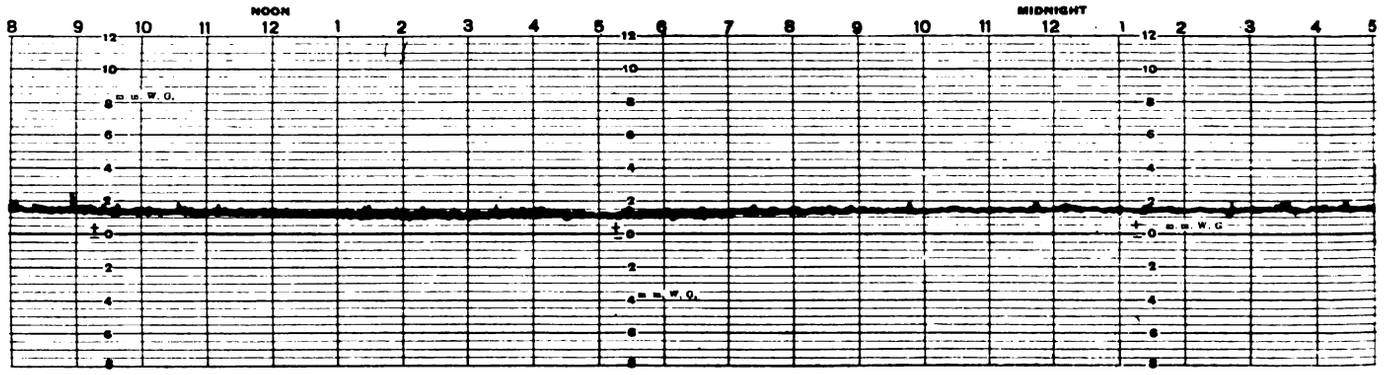

Chart which shows that in this case the regulation was very close and in no place varied more than 1 m.m.

This situation assigns a definite place to the regulator in question. It is very useful when only very little regulation is needed. It is self-evident that less and less battery regulation is required, as the number of ovens increases, the relative length of the pipe line grows, and the exhauster governor is more perfect. The chart offered in evidence by the builders of the governor comes from a plant where the pipe lines are several thousand feet in length and where changes of pressure are small and slow.

The fact that constant pressure at the collecting main can be obtained without any battery governors whatsoever is proven by foreign practice, in which the exhauster governor keeps the pressure constant within 1½ m.m. of water. Another method used in foreign practice consists in having a by-pass governor at the exhauster which also keeps the pressure constant and within 1 m.m. of water gauge. This practice is not cited here as a suggestion for imitation, but as proof that a good collecting main pressure chart is not necessarily a guarantee for the good qualities of a coke oven pressure regulator.

W. TRINKS.

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WITH THE EQUIPMENT MANUFACTURERS

CATERPILLAR TRACTOR.

The Cleveland Tractor Company, Cleveland, Ohio, has developed a small caterpillar tractor for industrial use. The chief advantage of the tractor is that it can move cars through the yards and even buildings without requiring a track and without injuring the surface over which it travels. By reason of its crawler-like design, its great power and unusual economy in operation, this new machine is fitted to

Cleveland tractor in use in steel mills as a substitute for the narrow-gauge railroad.

do a wide variety of work. Its small size—52 inches high by 50 inches wide—enables it to go through ordinary factory doors. The continuous traction possessed by the Cleveland and the perfect distribution of weight has decreased the pressure exerted on the ground to five pounds per square inch. It is rated to give 12 horsepower at the draw bar, and is equipped with a high-speed, heavy-duty four-cylinder motor, weighs 2,750 pounds, has a traction surface of 600 square inches, width of track six inches, and has three-point suspension.

WESTINGHOUSE BOOKLET.

"Oil Circuit-Breaker Accessories" is the title of a bulletin recently issued by the Westinghouse Electric & Manufacturing Company. No matter what combination of tripping and signaling may be required, you can be almost sure that this book will show you the means for obtaining it.

Trip-magnet frames and coils are listed for obtaining underload, undervoltage, overload, overvoltage, series and shunt trip; several and, in some cases, all of these can be applied on the same breaker to act with the standard automatic overload trip mechanism.

For controlling the operating circuit of electrically operated breakers, control switches are listed. These can be connected with signal lamps to indicate the position of the breaker; one style has signal lamps mounted on its coverplate. And to control the signal lamp circuits, "signal and shunt-trip cutout switches" are shown. These can be so connected as to light the proper lamps to indicate the position of the breaker at all times; they are also used to open the shunt-trip circuit when the breaker opens.

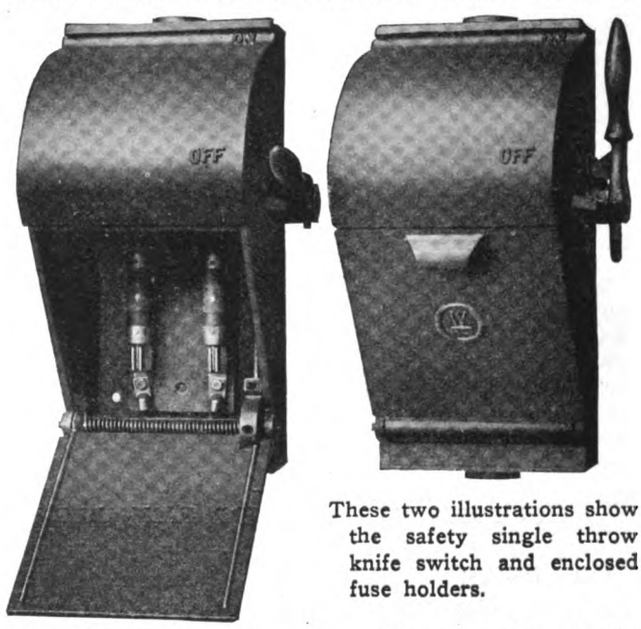
With a double-throw breaker, or with two single-throw breakers connected as a double-throw breaker, it is often desirable to have the throws so connected that with one throw closed it is impossible to close the other, and vica versa. This can be accomplished on electrically-operated breakers by interconnecting the operating circuit through a "signal and shunt-trip circuit" switch; with manually operated breakers, it is accomplished by interlocking bar with a suitable bracket.

And there are described and listed: signal switches, inverse-time element attachments; bell-alarm signal-contact attachments; bell-crank accelerating devices; universal mounting brackets for mounting breakers, instrument transformers, and other accessories on the rear of the panel or on a separate pipe or angle-iron frame.

A REAL "SAFETY-FIRST" SWITCH.

In steel mills, factories, mines, and similar places, employing men with practically no knowledge of electricity and its attendant risks, the need for an absolutely safe switch has become a necessity. The real safe switch is one so constructed that all live parts are totally enclosed and inaccessible. Means should also be provided for preventing operation by unauthorized persons.

The switch shown, which has been brought out by the Westinghouse Electric & Manufacturing Company, of East Pittsburgh, Pa., is typical of the real safety switch. Its use assures the maximum protection implied in the word "safety." The complete device consists of an ordinary single-throw knife switch and enclosed fuse holders mounted in an exceptionally strong cast iron box, with an operating handle outside the housing. The box is designed for conduit connection and has a partition separating the switch blades from the fuse holders.



These two illustrations show the safety single throw knife switch and enclosed fuse holders.

The upper or switch compartment can be opened only by removing two machine-screws. This compartment should never be opened except when making connections, or in case of inspection or repairs, as the switch is opened and closed by the operating handle, from the outside, through a shaft and lever inside the box.

The lower or fuse compartment, containing the fuses and fuse holders, is the only part of the switch that need be opened, and then only to replace blown fuses. The door of this compartment is so interlocked with the switch by a

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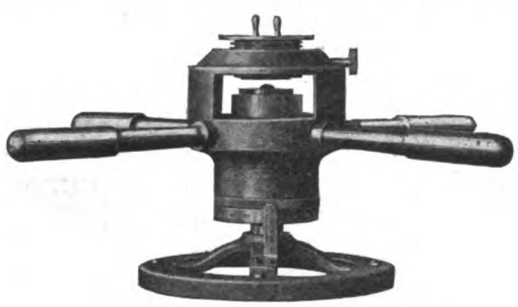
WITH THE EQUIPMENT MANUFACTURERS

vertically acting push rod which engaged a boss on the fuse-compartment door, that it can be opened only when the operating handle is in the off position and the circuit broken. Furthermore, with the door of this compartment open it is impossible to close the switch. Thus, the danger of a live line is eliminated.

The operating handle can also be locked with the switch in the open position, preventing tampering by unauthorized persons.

METAL SHEET TESTER.

The Pittsburgh Instrument & Machine Company has recently brought out a metal sheet tester, covered by patent, to determine the drawing, stamping, compressive and folding qualities of iron, steel, brass, copper, etc., sheets. In its construction the Pittsburgh metal sheet tester may be compared with a micrometer; the graduations permit measurements of the thickness of the material, and depth of impression by 1/1,000th of an inch. In examining the tested specimen the following points are observed: If the fracture runs in one certain direction the metal is fibrous and not very suitable for drawing and folding purposes. Should the structure of the dome appear rough or close grained, the cause may be found in excessive annealing. By observing the smoothness or roughness of the dome, an indication of the heat treatment and grain size of the metal is obtained. The character of the break will indicate not only the grain size, but will also show the presence of small cracks and other imperfections in the metal.



The Pittsburgh metal sheet tester.

CURTISS STEAM TURBINE FOR FANS, BLOWERS AND PUMPS.

The General Electric Company, of Schenectady, N. Y., has developed a Curtiss steam turbine in a wide variety of capacities to drive fans, blowers and pumps for boiler feeding and circulating systems.

It is called the Type L, and is of the impulse type. The number of stages and rows of buckets vary with the capacity. The principles used and mechanical practice evident in the construction are the result of the vast experience of the manufacturers in producing turbines for practically every class of service.

A split wheel casing is used to permit ready inspection of the buckets which are of bronze securely dovetailed into the rim of the wheel. The exhaust steam is free from oil and is well suited for heating feed water.

Speed regulation is close and reliable and the speed may be changed by hand wheel adjustment while the turbine is in operation. A constant running speed is maintained by a simple and powerful speed governor mounted directly on the shaft and controlling a double balance piston valve type throttle.

The main shaft carrying the turbine and governor runs on babbitted bearings with renewable linings, and is fitted with readily accessible packing glands.

Three feet support the rigid frame of the turbine to insure the bearings always being in line. The wheel casing is neatly lagged with planished iron.

SAFETY GOGGLES.

Something new in the way of a "safety" goggle, which, while made of glass, cannot actually be broken even with a hammer blow and which, moreover, on being cracked does not give rise to a flock of splinters which jeopardizes the eyesight of the wearer, is being offered by the Strong, Kennard & Nutt Company, Cleveland, O. "Resistal is the trade name of the glass used in the manufacture of these goggles. It comprises two layers of perfect optical glass, which may be either plain or curved, with a layer of celluloid interposed, the whole being welded—not cemented—into a solid mass. The result is a crystal which has every virtue common to the ordinary glass with none of its drawbacks or dangers; it has, moreover, all of the strength and safety features of the celluloid eyeshield, but unlike celluloid, it is absolutely unscratchable, is rigid, durable and perfectly fireproof. Neither is it affected by water, heat or cold and the celluloid provides a heat-insulating medium which effectively prevents "clouding up" due to moisture condensation.

MOTOR-DRIVEN WIRE POINTERS.

For those wire-drawing shops which prefer individual motor drive, the Morgan Construction Company, of Worcester, Mass., has arranged to supply its wire-pointing rolls with Westinghouse motors mounted on the frame. This makes the unit very compact, since there is no external apparatus and no overhead connections. It is also easy to start and stop by means of the conveniently located starting-box handle.

The wire-pointer consists simply of a pair of rolls revolving so as to feed material toward the operator. There are a number of grooves to care for various sizes of wire. The cross-section of these grooves diminishs around the circumference, so that the end of a wire placed in the open part of a groove is pushed back by the rolls and reduced into a tapering end. This pointed end is then threaded through the die in which the wire is to be drawn down.

PORCELAIN PYROMETER TUBES.

The Stupakoff laboratories, of Pittsburgh, Pa., have taken up the manufacture of Marquardt porcelain, for the purpose of protecting thermo-couples at furnace temperatures. The protection is called "Usalite." It is claimed by the manufacturers that tubes of this material will readily withstand exposure to temperatures exceeding 1,650 deg. C. A highly refractory glaze covers the surface of the outer pyrometer tubes in order to make them impervious to gases of combustion. In strength tests 5/16-inch unglazed inner tubes, on supports placed 5 inches apart, broke under a centrally applied load of 20 pounds. Outer tubes of standard size 11/16-inch diameter, submitted to the same test broke at 212 pounds.

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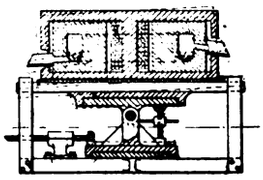
RECENT PATENTS

Induction Furnace.

1,240,460. David R. Knapp, Pottsville, Pa., assignor to the Eastern Steel Company, Pottsville, Pa., a corporation of Pennsylvania. The patent refers to an induction type of electric furnace. The



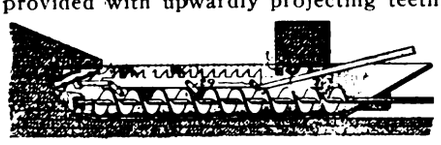
crucible is mounted for rotary movement. Means are provided for producing a maximum cross sectional area at one part of the trough on the crucible and a minimum cross sectional area at another part of the trough.

Binding Material.

1,233,384. Walther Mathesius, Berlin, Germany. The patent refers to binding material and method of preparation. The most important claims are as follows: The method of preparing a binding material for iron ore briqueting which consists in intimately mixing highly basic lime compounds with finely-divided oxids of iron and heating the mixture to a temperature not above the sintering temperature. The method of preparing a binding material for iron ore briqueting which consists in heating a mixture of a highly basic lime compound and finely divided oxids of iron to a temperature near but below the temperature where sintering occurs. The method of preparing a binding material for iron ore briqueting which consists in heating an intimate mixture of burnt dry-slaked lime and finely divided iron oxid to a temperature lying close to, but below the temperature where sintering occurs. The method of briqueting iron ore which consists in heating a mixture of ore and lime compound to a temperature near but below that where sintering occurs, adding additional ore, finely grinding the mixture, and molding or shaping the ground material.

Removing Open Hearth Slag.

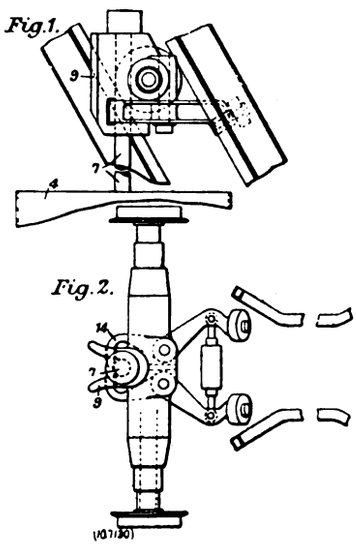
1,238,526. Walter A. Kosinski, Chicago, Ill. This patent provides a slag removing mechanism for removing open hearth slag from the slag pocket. Combs provided with upwardly projecting teeth



are placed near the side of the walls. These combs are actuated longitudinally and upwardly above the plane of the slag box, for the purpose of dislodging the slag. A screw conveyor is placed beneath the combs to remove the slag.

Blast Furnace Hoists

107,130. A. Sahlin, London. This invention relates to blast furnace hoists of the class in which charging buckets carried by trolleys are brought to the foot of a usually-inclined framework or track and there engaged respectively with a trolley frame or frames, which are guided by the framework and hoisted to the furnace top by means such as a rope or chain, the engagement being usually effected by causing the head of a ball, link, rod or like part attached to the bucket to be caught by a hook or Y-shaped piece, or like part, of the hoisting trolley. According to the present invention a safety device is provided for pre-



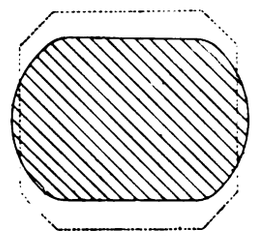
venting the bucket escaping from the hook or the like part carrying it, and preferably, also, from swinging during its travel on the framework at desired points thereon. This may be effected by providing the hook, Y-shaped piece, or the like 9 of the hoisting trolley with a bar, hook, tongs, nippers, or the like 14, which is, or are, adapted to be placed in front of the bail, link, rod, or the like 7 of the bucket 4, in such a position that it cannot escape from the hook, Y-shaped piece, or the like 9, of the hoisting trolley, until automatically released at the desired point.—Reported in "Engineering."

Blast Furnace Stock Level Indicator.

1,237,735. Paul D. Wright, Wilkinsburg, Pa. This patent consists chiefly of a try rod which is adapted to be lowered into the burden within the furnace, to determine the height thereof. When the bell is lowered the try rod records the addition to the height of the burden. Means are provided for automatically maintaining the try rod in engagement with the top of the furnace burden. The try rod is connected to an indicator.

Method of Rolling.

1,239,743. Charles Thickett and William Hawksworth, Deepcar, near Sheffield, England, assignors to Samuel Fox & Company, Ltd., Sheffield, England. This patent includes a method of rolling



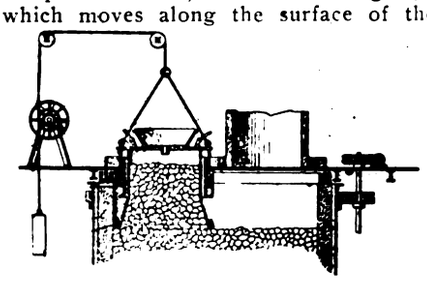
round bars which consists in first forming the bar such that two sides are rectilinear while the other two sides or ends are curvilinear and subsequently finishing the bar circular in cross-section.

Process of Manufacturing Iron and Steel.

1,233,970. Jegor Israel Bronn, Rombach, Germany, assignor of one-half to the firm of Rombacher Huttenwerke, Rombach, Germany. The patent comprises a process for manufacturing iron and steel consisting in preparing an iron bath of impure iron, refining the same by oxidation of the impurities and treating the bath oxygenated during the refining process with a phosphorus containing iron material to deoxidize the same. The process furthermore consists in preparing a phosphorus pig iron containing bath within a converter, subjecting the same to blowing in order to oxidize the impurities therein, continuing the blowing operation till the phosphorus of the bath is substantially removed and the bath oxygenated, removing the slag from the bath and adding a comparatively small proportion of phosphorus content.

Gas Producer.

1,240,220. Ebeneer A. W. Jefferies, Worcester, Mass., assignor to Morgan Construction Company, Worcester, Mass. The gas producer covered by this patent includes a chamber for the reception of fuel, and a fuel magazine which moves along the surface of the



fuel. There is a fuel delivery opening at the lower end of the magazine, at the side opposite the approaching fuel. Means are provided for imparting a rotative movement to the surface of the fuel in the gas producing chamber.

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Trade Publications

Electric Motors.—The Reliance Electric & Engineering Co., of Cleveland, O., has recently issued a new catalog describing their type A-S Reliance adjustable speed motors. Description of mechanical details, characteristic curves, starting and reversing equipment are included, as well as a great number of illustrations of typical installations.

Buckets, Cars, Etc. — The Biehl Iron Works, Inc., Reading, Pa., has published a new booklet giving data on coal and ore tubs, contractors' buckets, dump buckets, skips, side dump cars, charging cars, etc. The booklet is well illustrated.

Paints. — A booklet entitled "Complete Maintenance Painting Specifications," for manufacturing plants, storage buildings and power houses, has been issued by the Detroit Graphite Company.

Supplies. — Rails, locomotives,, equipment, machinery, steel piling, tanks, etc., are listed and described in Bulletin No. 220, published by the Walter A. Zelnicker Supply Company.

Electric Hoists. — Book No 246, entitled "Link-Belt Electric Hoists," gives overall dimensions, instructions, illustrations of an interesting nature. The details of construction are carefully explained.

Sheet Metal Tester. — The Pittsburgh Instrument & Machine Company, has issued a pamphlet descriptive of their metal sheet tester, which is described in detail in the "With the Equipment Manufacturers" column in this issue.

Plate Mills. — The United Engineering & Foundry Company has published a book—"United Plate Mills," which contains an unusual amount of actual data. It is well illustrated with plant layouts, plate mills, sheets, etc. European and American practices of rolling plates are compared. Valuable suggestions concerning heating furnaces are presented. Horsepower data compiled from a great number of sources are averaged. The booklet treats entirely with the manufacture of sheared plates, universal mills not being considered.

Hardness Testing Machines.—A booklet recently issued by the Scientific Materials Company, Pittsburgh, describes the operations of the Brinell hardness testing machine. The hydraulic press used for this purpose is provided with pumps, manometers and a ten-millimeter steel ball.

Oil Engines. — Oil engines designed for heavy duty service on portable machines are described in a catalogue recently distributed by the Minneapolis Steel & Machinery Company, Minneapolis.

Steel. — Various grades and finishes of electrical tool and alloy steels are described in a booklet issued by Peter A. Frasse & Company, Inc., New York. One of the valuable features included in the booklet are several sets of tables designed to supply the manufactures with the necessary specifications for making selections.

Department of the Interior, Bureau of Mines, has issued the following new publications: Bulletins—Bulletin 120, "Extraction of Gasoline from Natural Gas by Absorption Methods," by G. A. Burrell, P. M. Biddison and G. G. Oberfell. 1917. 71 pp., 2 pls., 17 figs. Bulletin 138, "Coking of Illinois Coals," by F. K. Ovitz. 1917. 71 pp., 11 pls., 1 fig.

Technical Papers—Technical Paper 147, "Absorption of Methane and other Gases by Coal," by S. H. Katz. 1917. 22 pp., 4 figs. Technical Paper 149, "Answers to Questions on the Flotation of Ores," by O. W. Ralston. 1917. 30 pp. Technical Paper 150, "Limits of Complete Inflammability of Mixtures of Mine Gases, and of Industrial Gases With Air," by G. A. Burrell, and A. W. Gauger. 1917. 13 pp., 2 figs. Technical Paper 156, "Carbon Monoxide Poisoning in the Steel Industry," by J. A. Watkins. 1917. 18 pp., 1 fig. Technical Paper 169, "Permissible Explosives Tested Prior to March 1, 1917, by S. P. Howell. 1917. 19 pp., 1 fig.

Note—Only a limited supply of these publications is available for free distribution and applicants are asked to coöperate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers can not be granted. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

Trade Notes

E. B. Hotchkiss, of the American Steel Export Company, has sailed on the steamship Chicago, for France. Mr. Hotchkiss will visit France, Italy, and Spain, in connection with a number of very large engineering problems. Incidentally he will make certain investigations in these countries for the American Steel Export Company and also act as a special representative of the engineering department in that part of the world.

The Asbestos Protected Metal Company, of Pittsburgh, announces the appointment of C. A. Crowe, formerly manager of the Grand Rapids office, to take charge of the Detroit office, located in the Penobscot building. M. W. Taber, formerly Detroit manager, has been appointed factory manager.

H. E. Derbyshire, general manager of the Chambersburg Engineering Company, has resigned, effective September 10.

F. H. Willcox has resigned from the Huessener Enginering Company, to become associated with Freyn & Company.

The Homestead Valve Manufacturing Company, of Homestead, Pa., announces that it has almost completed the rebuilding of its manufacturing plant and office buildings, whereby it added about 75 per cent additional space to take care of the increase in its business. In addition to adding more floor space in its factory and offices, the Homestead Valve Manufacturing Company has also added considerable new machinery and equipment, especially in the foundry, where the production has been almost doubled in a short time.

Chester H. Lehman, for the past six years secretary and director of the Blaw-Knox Company, has entered the service of the United States government for the duration of the war, as first lieutenant in the ordnance department.

Society Meetings

American Electro-Chemical Society, Pittsburgh, Pa., October 3-6.

Philadelphia section of the Association of Iron and Steel Electrical Engineers, October 6, Majestic Hotel, Philadelphia.

American Institute of Mining Engineers, St. Louis, October 8-13.

Annual Congress of the National Association of Purchasing Agents, Pittsburgh, William Penn Hotel, October October 9-11.

Engineers' Society of Western Pennsylvania, October 16, monthly meeting Union Arcade, Pittsburgh.

American Gas Institute, Washington, D. C., October 16-19.

Fall session of the American Iron and Steel Institute, Hotel Sinton, Cincinnati, October 26-27.

American Society of Mechanical Engineers, New York City, December 26-29.

American Mining Congress State Chapter, Phoenix, Ariz., December 26-29.

American Society of Mechanical Engineers. Monthly meeting, first Tuesday. Calvin W. Rice, secretary, 29 West Thirty-ninth street, New York City.

Providence Engineering Society. Monthly meeting, fourth Wednesday of each month. A. E. Thornley, corresponding secretary, P. O. Box 796, Providence, R. I.

New England Foundrymen's Association. Regular meeting, second Wednesday of each month, Exchange Club, Boston, Mass. Fred F. Stockwell, 205 Broadway, Cambridgeport, Mass.

Rochester Society of Technical Draftsmen. Monthly meeting, last Thursday. O. L. Angevine, Jr., secretary, 857 Genesee street, Rochester, N. Y.

Western Society of Engineers, Chicago, Ill. Regular meeting, first Wednesday evening of each month, except July and August. E. N. Layfield, secretary, 1785 Monadnock Block, Chicago, Ill.

Technical League of America. Regular meeting, second Friday of each month. Oscar S. Teale, secretary, 35 Broadway, New York City.

Philadelphia Foundrymen's Association. Meetings, first Wednesday of each month. Manufacturers' Club, Philadelphia, Pa. Howard Evans, secretary, Pier 45 North, Philadelphia, Pa.

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